JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 23 MARCH 15, 1933 No. 3

PHYSICS:—*Some improvements in psychrometry.*[1]

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MODIFIED PSYCHROMETER

Some modifications in psychrometry which may be of interest to meteorologists have been developed in the course of other research work at the Bureau of Standards. The research in question involved the continuous measurement of humidity under conditions considered rather extreme for the ventilated psychrometer, as can be appreciated from the fact that relative humidities lower than 5 per cent at dry bulb temperatures of nearly 150°F were included in the measurements.

An investigation of the conventional ventilated psychrometer under such conditions showed that it did not correctly indicate the humidity, when the Ferrel formula[2] was used. The psychrometric constant required to give a correct value of the humidity increased with an increase either in temperature or in wet-bulb depression. Experiment indicated that this occurred because the temperature of the water in the wet-bulb supply tube was materially above the wet-bulb temperature. Consequently, if sufficient water were supplied to the wick to keep it wet, the water, not being cooled sufficiently by evaporation before reaching the bulb, raised the temperature above evaporation temperature.

Increasing the length of exposed wick between the supply tube and the bulb did not correct this condition, as the resultant diminished water supply to the wet bulb was not adequate to maintain wetness under conditions causing wet-bulb depressions of over 60 Fahrenheit degrees.

[1] Received November 26, 1932.
[2] Report of Chief Signal Officer, U.S.A., 1886. p. 249.

It was obvious that better, if not satisfactory, results could be obtained by maintaining the water supply at or near wet-bulb temperature. This was accomplished automatically in both of the two modified types of psychrometer which are shown in Figures 1 and 2. In both of these instruments the air supply is passed over the dry and wet-bulb thermometers as in other ventilated psychrometers. In the instrument shown in Figure 1, the air which has passed the thermometers is passed over the wet-bulb water-supply tube, which is electroplated with silver, perforated by a number of small holes, and surrounded with a wick, thus constituting an auxiliary wet bulb. In this apparatus this auxiliary wet bulb is in the wake of the thermometric wet bulb. The apparatus shown in Figure 2 is similar, except that both the thermometer wet bulb and the auxiliary wet bulb are cooled by the air the humidity of which is to be determined. The instrument illustrated in Figure 1 is adapted to conditions where the volume of air to be handled is small, while that illustrated in Figure 2 may be used where the volume is large.

Since the auxiliary wet bulb, in the first case mentioned, is in the wake of the thermometric wet bulb, it cannot attain as low a temperature as the latter. In practice, however, the temperature of the wet-bulb water supply was within one or two Fahrenheit degrees of the temperature of the thermometric wet bulb. This difference caused no difficulty, as was indicated by the invariance of the psychrometric constant. In the second case, both the thermometric and the auxiliary wet bulbs are cooled by air of the same humidity, and the water supplied was cooled practically to evaporation temperature before reaching the thermometer wick.

TABLE 1.—CONSTANT A_0, OF MODIFIED PSYCHROMETER

No. Runs	No. Obs.	Equivalent Altitude ft.	Dry Bulb °C	Rel. Hum. per cent	A_0	Comparison
11	53	Sea Level	Over 60	*ca.* 7	0.000642	Psychrometer[a]
1	1	" "	56.8	0.6	0.000656	"
7	7	" "	*ca.* 20	Over 80	0.000638	"
1	8	12,500	*ca.* 27	*ca.* 30	0.000646	"
1	14	28,000[b]	*ca.* 25	*ca.* 20	0.000663	"
1	2	30,000[b]	*ca.* 21	*ca.* 25	0.000678	"
58	217	Sea Level	21 to 64	0.6 to 64	0.000648	"
14	53	" "	21 to 65	5 to 63	0.000650	Chem. Analysis

[a] Checked against a comparison psychrometer, the latter operating under favorable conditions. See Appendix.

[b] Subject to rather large errors because pulsation in air stream rendered air pressure measurements uncertain. Exhaust pump operating at capacity. Note that only 2 observations were taken at 30,000 ft.

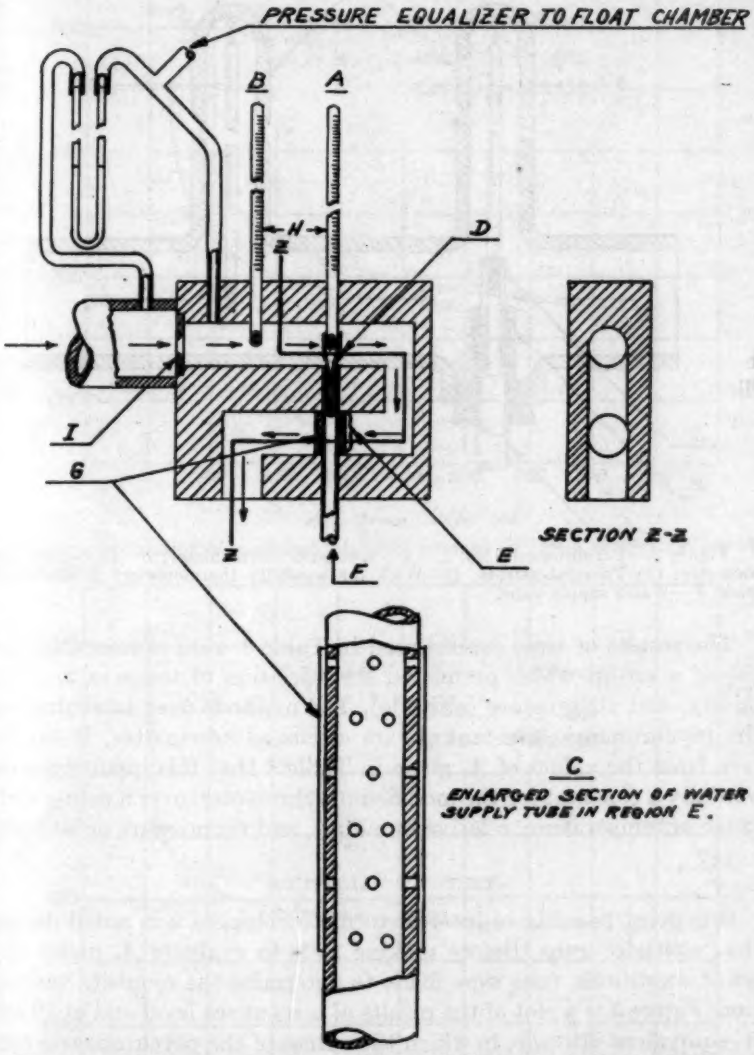


Figure 1.—Psychrometer No. 1. *A*—Wet-bulb thermometer; *B*—Dry-bulb thermometer; *C*—Enlarged section of water supply tube (*F*) in region (*E*); *D*—Wick for wet-bulb thermometer; *G*—Auxiliary wet bulb; *H*—Minimum distance between thermometers; *I*—Orifice.

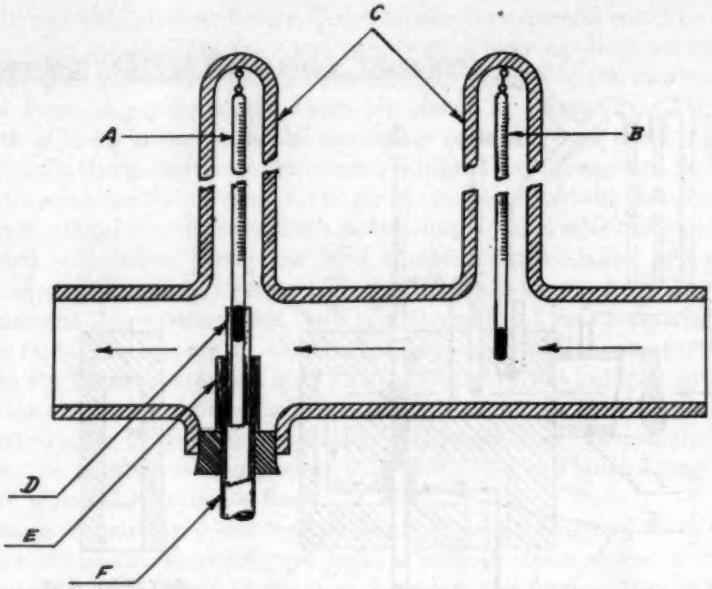


Figure 2.—Psychrometer No. 2. *A*—Wet-bulb thermometer; *B*—Dry-bulb thermometer; *C*—Thermal shields; *D*—Wick for wet-bulb thermometer; *E*—Auxiliary wick; *F*—Water supply tube.

The results of tests summarized in Table 1 were obtained by the use of a set-up which permitted the variation of temperature, humidity, and air pressure (altitude). The methods used in evaluating the psychrometric constant A_0 are discussed hereinafter. It can be seen from the values of A_0 given in Table 1 that this quantity is essentially a constant for the modified psychrometer, over a rather wide range of temperature, relative humidity, and air pressure or altitude.

TESTS AT "ALTITUDE"

One point possibly of interest to meteorologists was noted during the "altitude" runs. Before making tests to evaluate A_0 under any set of conditions, runs were made to determine the requisite ventilation. Figure 3 is a plot of the results of tests at sea level and at 29,500 ft. equivalent altitude, in which the values of the psychrometric constant, corrected to 0°C, are plotted against the ventilation, expressed as average air speed past the instrument in cm. per second. It is apparent that the requisite speed is higher at the lower air pressure. The relation of the two is made obvious when the constant is plotted

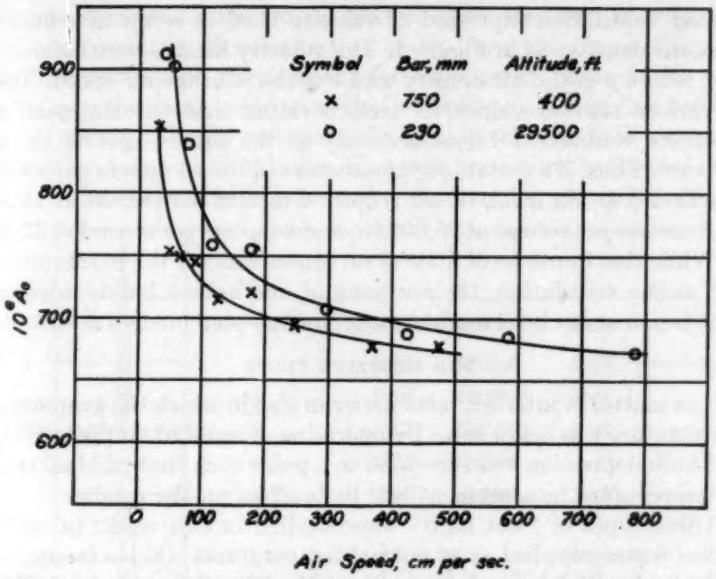


Figure 3.—Variation of coefficient "A_0" with average air speed, at sea level and at 29,500 feet.

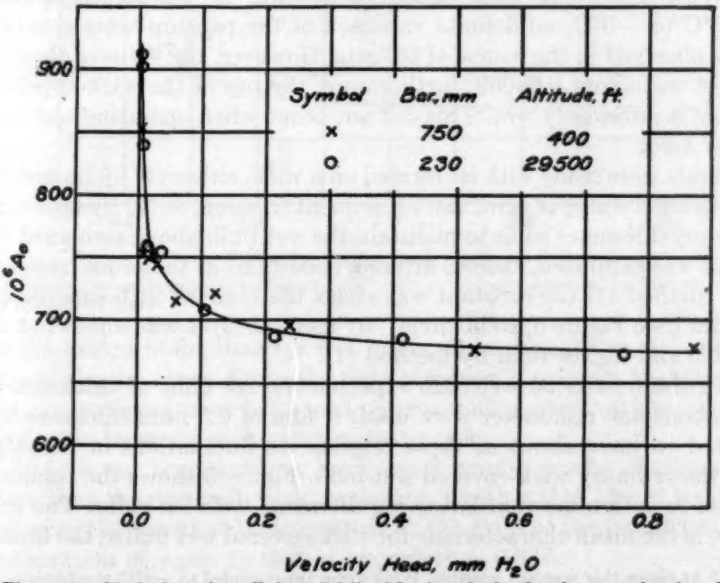


Figure 4.—Variation of coefficient "A_0" with air velocity head, at sea level and at 29,500 feet.

against ventilation expressed as velocity head in terms of a fluid of constant density, as in Figure 4. The velocity head is here defined as $\frac{1}{2}\rho v^2$, where ρ is the air density and v is the average air speed. Tests at various altitudes agree in demonstrating that the air speed for adequate ventilation varies inversely as the square root of the air pressure. Thus, if a certain psychrometer requires 3 meters per second ventilation at sea level, it will require 4 meters per second at 15,000 ft., 5 meters per second at 25,000 ft., and 6 meters per second at 32,000 ft. While this would be of little or no consequence if the psychrometer had ample ventilation, the accuracy of one having barely adequate ventilation at sea level might be impaired at even moderate altitudes.

SUB-FREEZING TESTS

As a matter of interest, tests were run also in which the evaporation temperature was below zero. By operating at reduced air pressure, the wet bulb depression was increased to a point such that residual errors of temperature measurement had little effect on the results.

Three types of "wet bulb" were studied in this work: (*a*) supercooled water supplied as at normal temperatures; (*b*) ice frozen on a wick; and (*c*) ice formed as a coat on the bare thermometer bulb.

When operating with supercooled water at temperatures from −2°C to −6°C, no definite variation of the psychrometer constant was observed in the course of 30 tests. However, the value of the constant was about 0.00069; furthermore, the top of the wick appeared to be insufficiently wet. This did not occur when operating above or near zero.

Tests were made with ice formed on a wick, either (1) by immersion in distilled water at zero, and subsequent freezing, or (2) by operating the psychrometer so as to maintain the wet bulb above zero until the wick was saturated, then so altering conditions as to induce freezing.[3] By method (1) the constant was about the same as with supercooled water (See Figure 5, solid circle); by method (2) it was somewhat variable and higher than by method (1).

In the ice-coated wet-bulb experiments, ice films of thickness up to about one millimeter were used. A film of 0.5 mm. thickness was noted to have about as rapid response to fluctuations in humidity as the ordinary wick-covered wet-bulb. Figure 5 shows the results of tests to determine ventilation requirements with ice bulbs. The solid line is the mean characteristic for wick-covered wet bulbs; the broken

[3] At times this was not possible. With water super-cooled to −5°C, mechanical agitation of the wick frequently failed to cause freezing.

line represents the same values multiplied by the ratio of the latent heat of evaporation of water to that of ice. From this figure it appears that the ventilation requirement for ice-covered bulbs varies with altitude in the same manner as that of ordinary wet bulbs; further, there appears to be no material difference in the ventilation requirement of ice bulbs and wet bulbs. However, ice-coated bulbs cool more slowly. The effect of this is to make the time lag somewhat greater

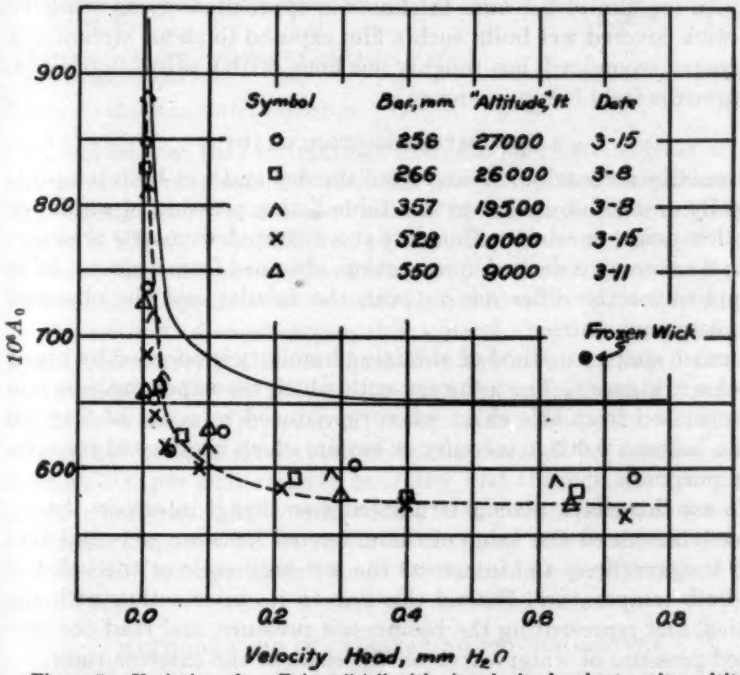


Figure 5.—Variation of coefficient "A_0" with air velocity head, at various altitudes for ice-coated bulbs.

for ice-coated bulbs than for wet bulbs, even though the response is essentially the same. From the data obtained it appears that:

1. At temperatures near zero, psychrometer observations should if possible be made with super-cooled water;

2. At lower temperatures, more exact results can be obtained by discarding the wet-bulb wick, replacing it with a thin film of ice, and reducing the constant in proportion to the ratio of the latent heat of evaporation of water to that of ice, which is 0.882.

3. The ventilation velocity required will be the same in this case

as with the ordinary wet bulb; the time required to reach evaporation temperature will be roughly four times that with the wet bulb.

4. If a frozen wick is used, the constant required is the same as that for water. This fact may be ascribed to two factors, tending to produce opposite effects, approximately equal in amount, namely, the lower value of the constant required with ice, and the partial drying of the wick, in the time required to reach equilibrium.

5. An ice film of 0.5 mm. thickness is approximately as sensitive as a wick covered wet bulb; such a film exposed to an air stream of 5 meters per second will last roughly one hour, with a saturation deficit of approximately 3 mm. mercury.

A NEW PSYCHROMETRIC CHART

Humidity ordinarily is found from the dry and wet-bulb temperatures by double interpolation in a table listing pressure of water vapor, dew point, or relative humidity at a definite barometric pressure; then, if accuracy is desired, a correction, obtained from a second table is applied for the difference between the tabular and the observed barometric pressures.

A much simpler method of obtaining humidity is afforded by use of the chart, Figure 6. The accuracy with which the vapor pressure can be estimated from this chart when reproduced to a size of 8 by 10 inches is about 0.005 in mercury or better, which is sufficient for ordinary purposes.

To use this chart, place a straightedge so that it intersects the extreme left scale at the value of the difference between wet- and dry-bulb temperatures, and intersects the wet-bulb scale at the value of wet-bulb temperature. Extend this line to its intersection with the vertical line representing the barometric pressure, and read the corrected pressure of water vapor on the scale at the extreme right.

To determine the relative humidity, transfer the value of the pressure of water vapor thus obtained to the same value on the heavy vertical line representing standard barometric pressure. Connect by a straight line the point so obtained and the point representing the value of the dry bulb temperature on the diagonal line marked "Dry Bulb." Extend this line to its intersection with the vertical line on the left, and read the relative humidity on the inner left scale.

In obtaining the pressure of water vapor when the wet-bulb temperature is below freezing, the "Wet Bulb" scale is employed if the psychrometer was used with either supercooled water or a frozen wick. However, if the evaporation temperature was obtained with an

ice-coated thermometer, the "Ice Bulb" scale, to the right of the "Wet Bulb" scale, must be used.

The precision and time saving resulting from use of the chart instead of computations from the psychrometric formula or estimation from the Psychrometric Tables[4] was found from a series of timed computations, and is shown in the following tabulation:

	Formula	Tables	Chart
Average deviation from computed humidity value, in. Hg	—	0.0036	0.0021
Average deviation from computed values of relative humidity, per cent	—	0.40	0.36
Relative time required for estimation	6	2	1

It will be seen that estimations from the chart are at least as precise as are determinations from the tables, and are twice as rapid. This information was obtained using a preliminary chart, not as precise as is Figure 6. Estimation of humidity from a chart, 16 by 20 inches in size, should not appreciably impair the precision even of results obtained by use of the modified psychrometers described herein.

The method of constructing this type of chart is described elsewhere,[5] except for the scales of relative humidity and dry bulb temperature. The "Dry Bulb" scale lies on a line connecting zero relative humidity with zero pressure of water vapor; the point on this line corresponding to a given temperature is located by passing a line through 100 per cent relative humidity and through the saturation pressure (scale at right) corresponding to the temperature in question. The point required lies at the intersection of this line with the dry bulb scale. This operation should be done analytically rather than graphically.

METHODS USED IN CALIBRATING PSYCHROMETERS

Calibration of a psychrometer by comparison with humidity values obtained by absorption methods, while precise if done by an expert technician, is laborious. Calibrations by comparison with another psychrometer, drawing air from the same source, may be made readily and rapidly, and under proper conditions are accurate.

Three methods of calibration by comparison with another psychrometer have been utilized in this work. In no case is it necessary to compute the actual humidity of the air supply. All methods are based on the applicability of the general psychrometric formula, and

[4] W. B. No. 235, 1912.
[5] Bureau of Standards Jour. of Research, Nov. 1929. 795.

on the premise that both psychrometers draw air from the same source.[6]

The first of these methods, which was developed for the study of the modified psychrometer at high temperatures and low humidities,

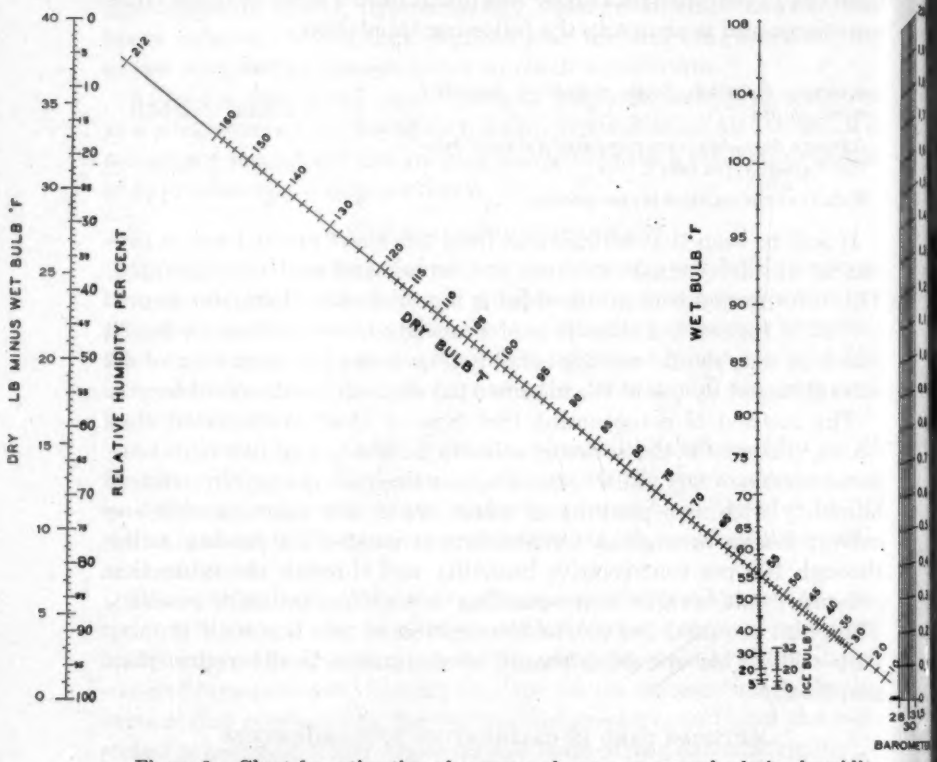


Figure 6.—Chart for estimation of pressure of water vapor and relative humidity from psychrometric observations.

consists in comparing its readings with those of another psychrometer, the latter drawing air from the same source but at a temperature(or pressure) in the range known to allow accurate measurement of humidity. Even when the humidity is not accurately determined, it can be shown mathematically that the constant found for the test psychrometer will be but little affected thereby.

The second method was developed for study of the modified psychrometer at reduced air pressures, simulating altitude operation.

[6] See appendix for theory involved in these methods.

One of the two identical psychrometers was operated at sea-level pressure (hence under known conditions) and the other at reduced pressures. As a study of the results by means of the first method (above) showed no marked deviation of the constants of the two instruments from the theoretical value, a mean value of the constant will be obtained by assuming the constants of the two psychrometers to be identical. The mean constant was thus obtained without the necessity of assuming a value of the constant for either instrument. This method is applicable to operation at different temperatures as well as at different pressures.

TABLE 2.—DETERMINATION OF PSYCHROMETER CONSTANT

	Comparison Psychrometer		Test Psychrometer	
Run No.	1	2	1	2
Barometer, mm. Hg	748.6	748.3	485.5	748.3
Dry Bulb, °C	4.80	4.79	5.65	4.54
Wet Bulb, °C	−0.63 (water)	−0.60	−3.12 (ice)	−1.14
Constant, 3rd Method	0.000653		0.000570	
Theoretical constant	0.000652		0.000575	
Constant, 1st Method	(Assumed 0.000652)		0.000570	0.000569

If, as in the case of the ice-bulb tests, there is a theoretical reason why the constants should not be equal for the two instruments, the second method, above, is not applicable. To meet this case, and to obviate the necessity inherent in the first method, for assuming the value of the constant of the comparison psychrometer, a third method was developed. This method requires readings on both psychrometers under not less than two sets of conditions. The more diverse the conditions are for either psychrometer, the more precise is the value of the constant obtained for it. By this method, the constant is separately obtained for each psychrometer, the sole assumption being that each constant, corrected for variation of latent heat of evaporation with temperature, is the same under the two sets of conditions.

The following example serves to illustrate the use of this method. In one of the "ice-bulb" tests, the comparison psychrometer was operated at sea-level pressure, using supercooled water, while the test psychrometer, operated first at reduced pressure, then at sea-level, had an ice-coated thermometer serving as the "wet bulb." The observations and results are given in Table 2.

Table 3 gives an idea as to the relative precision to be expected of each of the comparison methods described above, under representative conditions.

From this table it is apparent that, even if it be assumed that no error is involved in the chemical measurement of humidity the probable error of the psychrometric constant as determined by these comparison methods is such as to recommend their use, in view of the much greater rapidity with which determinations can be made.

TABLE 3.—COMPARISON OF METHODS FOR EVALUATING THE PSYCHROMETRIC CONSTANT

GENERAL ASSUMPTIONS

Air to test psychrometer at 30°C except Method *D*, Case 2; pressure of water vapor 1 per cent of total pressure. The probable error of the psychrometric constant is given as millionths of a unit per hundredth of a degree probable error in temperature measurements.

Method	Specific Assumptions	Error of $A(\times 10^6)$
A—Chemical comparison	Chemical error zero	1
B—Psychrometric comparison	Comparison psychrometer air at 10°C; its constant assumed $(660 \pm 30) \times 10^{-6}$	1.4
C—Psychrometric comparison	Constants assumed equal. Test psychrometer at 380 mm. Hg. pressure, comparison psychrometer at 760	3.3
D—Psychrometric comparison	No assumptions regarding constants. Case 1. One set of runs with test psychrometer at 760 mm. Hg., comparison at 380; second set with pressures reversed	5.8
	Case 2. One set, one dry bulb 30°C, other 60°C; second set temperatures reversed.	0.74

APPENDIX

CALIBRATION OF PSYCHROMETERS BY INTERCOMPARISON

The general psychrometric formula is

$$E = E' - A_0 B(T - T')(1 + CT') \qquad (1)$$

where

E = pressure of water vapor
E' = vapor pressure of water (saturation pressure) at temperature T'
B = barometric pressure
T = air temperature
T' = evaporation temperature
A_0 = psychometric constant at 0°C
C = factor dependent on variation of latent heat of evaporation with temperature.

In the subsequent equations, capital letters refer to the comparison, or standard psychrometer, and lower case letters, having the same meanings, to the test psychrometer. Since both draw air from the same source,

$$\frac{E}{B} = \frac{e}{b}. \tag{2}$$

From equations (1) and (2) the formulae for the three comparison methods are derived.

First Method

Value of A_0 assumed; value of a_0 required

From (1) and its counterpart

$$e = e' - a_0 b(t - t')(1 + ct') \tag{3}$$

and from equation (2) above,

$$a_0 = \frac{Be' - bE' + A_0 Bb(T - T')(1 + CT')}{Bb(t - t')(1 + ct')}. \tag{4}$$

Formula (4) enables evaluation of the test psychrometer constant.

Second Method

a_0 assumed equal to A_0

From equations (1), (2) and (3), and the above assumption,

$$a_0 = A_0 = \frac{Be' - bE'}{Bb[(t - t')(1 + ct') - (T - T')(1 + CT')]}. \tag{5}$$

If, as is the case when both wet bulbs are using water, $c = C$, formula (5) may be simplified accordingly.

Third Method

A_0 and a_0 to be evaluated

To simplify the equations, let

$$x = (T - T')(1 + CT')$$
$$y = (t - t')(1 + ct')$$
$$z = \frac{Be' - bE'}{Bb}$$

and let the subscripts 1 and 2 denote the values for the successive sets of conditions under which each psychrometer is operated.

Then from formulae (1) and (2)

$$\begin{aligned} A_0 x_1 - a_0 y_1 &= z_1 \\ A_0 x_2 - a_0 y_2 &= z_2 \end{aligned} \tag{6}$$

and

$$\begin{aligned} A_0 &= \frac{y_1 z_2 - y_2 z_1}{x_2 y_1 - x_1 y_2} \\ a_0 &= \frac{x_1 z_2 - x_2 z_1}{x_1 y_1 - x_1 y_2}. \end{aligned} \tag{7}$$

If more than two observations on each psychrometer are to be included, the general equation

$$A_0 x - a_0 y = z \tag{8}$$

is solved for the psychrometric constants. Using the method of Least Squares

$$A_0 = \frac{\Sigma y^2 \Sigma xz - \Sigma xy \Sigma yz}{\Sigma x^2 \Sigma y^2 - (\Sigma xy)^2}$$
$$a_0 = \frac{\Sigma xy \Sigma xz - \Sigma x^2 \Sigma yz}{\Sigma x^2 \Sigma y^2 - (\Sigma xy)^2}. \qquad (9)$$

BOTANY.—*New grasses from Kashmir.*[1] A. S. HITCHCOCK, Bureau of Plant Industry.

Recently there was received for identification, from Dr. E. D. Merrill, Director of the New York Botanical Garden, a package of grasses collected in Kashmir, by Walter Koelz, for the Urusvati Himalayan Research Institute, Roerich Museum, Naggar (Punjab), India. The specimens were transmitted to Dr. Merrill by Dr. R. R. Stewart, Professor of Biology in Gordon College, Rawalpindi, India. Among them were two undescribed species, one of which represents a new genus.

The new genus belongs to the tribe Chlorideae, and is allied, though not closely, to *Leptochloa* and to *Trichoneura*. The type species was collected at an altitude of 15,500 feet, which fact suggested the generic name (from one of the Greek words meaning a mountain dweller), and was found growing on sand dunes, which fact suggested the specific name.

The other species belongs to a genus of which only two species, both Asiatic, were previously known. The original, or type species, was described a few years ago by the Russian botanist Roshevitz (*Timouria saposhnikowi* Roshev.) from a specimen collected in the Tian-Shan, Turkestan. A few years later I proposed a new genus of grasses based upon a species (*Psammochloa mongolica* Hitchc.), from Mongolia. Soon after the publication of this genus I discovered that it was the same as *Timouria* of Roshevitz (his publication having been inaccessible because of the World War) but was based upon a different species.[2] Now a third species comes to our attention from Kashmir. The genus *Timouria* is allied to *Oryzopsis*.

Timouria aurita Hitchc., sp. nov.

Perennis, glauca; rhizomata repentia; culmi erecti, scaberuli, 60 cm. alti, nodis glabris; vaginae retrorso-scaberulae, inferioribus albidis; ligula membranacea, ciliata, 1 mm. longa; laminae erectae, involutae, scabrae, 10–30 cm. longae, 1–3 mm. latae, apice pungente; panicula angusta, pallens vel

[1] Received November 8, 1932.
[2] For a discussion of this subject see This JOURNAL 17: 140. 1927, and 18: 502. 1928.

purpurascens, circa 10 cm. longa, ramis appressis, inferioribus inferne nudis; spiculae brevipedicellatae, pedicellis scabris; glumae membranaceae, acutae, scaberulae, 7 mm. longae; lemma villosum, glumis paulo brevius, apice bidentato, dentibus setiformibus, 3–4 mm. longis; arista curvata, persistens, 1 cm. longa.

Fig. 1.—*Timouria aurita*. Glumes and floret ×5 dia.; summit of lemma ×10 dia.

Fig. 2.—*Orinus arenicola*. Upper part of panicle, natural size; spikelet ×5 dia.

Perennial, with slender hard scaly rhizomes; foliage glaucous, the lower part of the plant pale or whitish; culms erect, scaberulous, about 60 cm. tall, the nodes glabrous; sheaths retrorsely scaberulous; ligule membranaceous, lacerate and ciliate, 1 mm. long or less; blades erect, scabrous, flat or mostly involute, 10 to 30 cm. long, 1 to 3 mm. wide, attenuate to a fine sharp whitish point; basal prophylli prominent, 5 to 10 cm. long, sharp-pointed; panicle narrow, pale or purplish, 10 cm. long, the branches appressed, the lower somewhat remote, naked below, these and the short pedicels scabrous; glumes nearly equal, rather broad, membranaceous, 3-nerved, acute, scaberulous, about 7 mm. long; lemma a little shorter than the glumes, densely long-villous, 3-nerved, bidentate, the teeth setiform, 3 to 4 mm. long; awn from between the teeth of the lemma, somewhat curved, not twisted, persistent, scaberulous, about 1 cm. long.

Type in U. S. National Herbarium, no. 1535770, collected in sand at Kugzil, Rupshu, Kashmir, Western Himalayas, India, alt. about 4300 meters, July 16, 1931, by Walter Koelz (no. 2328).

This species differs from the others in the setiform teeth of the lemma and in the more persistent awn.

Orinus Hitchc., gen. nov.

Spiculae pauciflorae, secus rhachin continuam breviter pedicellatae; rachilla teres, glabra, supra glumas et inter flores articulata; glumae membranaceae, acutae, paulum inaequales; lemmata prominente 3-nervia, villosa, obtusiuscula, mutica, apice integro. Gramen perenne, rhizomatibus repentibus; racemi secus axem erectum adscendentes; culmi caespitosi, erecti; laminae planae vel involutae. (*ὀρεινός*, a mountaineer.)

Spikelets few-flowered, short-pediceled in one row along one side of a continuous rachis, appressed, the rachilla disarticulating above the glumes and between the florets, the flowers perfect; glumes membranaceous, acute, slightly unequal; lemmas prominently 3-nerved, villous, awnless, the obtusish apex entire. Perennial, with creeping rhizomes; panicle of several racemes along an elongate erect axis; culms cespitose, erect; blades flat, becoming involute.

Type species, *Orinus arenicola*.

This genus differs from *Leptochloa* Sect. Diplachne, and from *Trichoneura*, in the entire awnless apex of the lemmas and in the villous pubescence evenly distributed over the lemma instead of confined to the nerves.

Orinus arenicola Hitchc., sp. nov.

Culmi glabri, 30–50 cm. alti; vaginae villosae vel glabrescentes; ligula 1 mm. longa; laminae 1–3 mm. latae, apice pungente; panicula 5–15 cm. longa; racemi 5–8, recti, 1–7 cm. longi; spiculae 2–3-florae; glumae 4–5 mm. longae; lemmata 3.5–4 mm. longa.

Culms cespitose, firm, erect, slender, glabrous, 30 to 50 cm. tall, from hard scaly creeping rhizomes; sheaths rather densely to sparsely villous, the lower glabrous, yellow; ligule about 1 mm. long, thin, lacerate; blades flat, becoming involute, sparsely pilose, 3 to 10 cm. long, 2 to 5 mm. wide, the apex sharp and finally hard; panicle 5 to 15 cm. long, with 5 to 8 erect or ascending racemes 1 to 7 cm. long, the lower naked at base; spikelets pale or leaden-purplish tinged, about 6 mm. long, 2 to 3-flowered, rarely 4-flowered, the rachilla slender, glabrous, the internode between the first and second floret about 1 mm. long; glumes pale, 4 to 5 mm. long, sparsely villous to nearly glabrous, acute, the first 1-nerved, the second 3-nerved; lemmas dark, often spotted, 4.5 to 5 mm. long, keeled, somewhat concave between the nerves, the obtusish tip hyaline; palea about as long as the lemma, villous; stamens 3, the anthers 3 mm. long; stigmas 2, plumose.

Type in the U. S. National Herbarium, no. 1535771, collected in bare sand, at Tsaka, Ladak, Kashmir, Western Himalayas, India, alt. 4700 meters, July 18, 1931, by Walter Koelz (no. 2365).

BOTANY.—*A new grass from Texas.*[1] AGNES CHASE, Bureau of Plant Industry.

Within the last year four previously unknown grasses were discovered in Texas. Recently another, not closely related to any other North American species, was sent to the Grass Herbarium by Mr. J. F. Combs, county agricultural agent, Beaumont, Texas. This grass has been found in three places only, all in Jefferson County, eastern Texas. Besides these new species several grasses not previously known from the United States have been found in Texas.

Paspalum almum Chase

Planta perennis caespitosa; culmi compressi, simplices, 30–50 cm. alti; vaginae carinatae glabrae; laminae 5–17 cm. longae, 2–3 mm. latae, basi hirsutae; racemi 2–3, approximati, 5–9 cm. longi; rhachis 1 mm. lata; spiculae solitariae, 3 mm. longae, 1.8–2 mm. latae, glabrae; gluma 5-nervis; lemma 5-nerve.

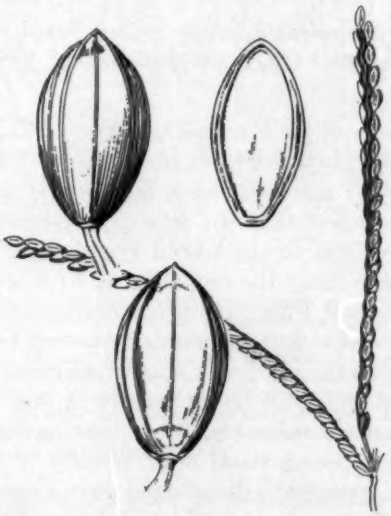


Fig. 1.—*Paspalum almum.* Inflorescence, natural size; two views of spikelet and one of fruit × 10 dia.

A densely tufted perennial; culms ascending to spreading, simple, 30 to 50 cm. tall, flattened, glabrous; leaves crowded toward the base; sheaths keeled, glabrous, the lower overlapping; ligule pale, membranaceous, about 1.5 mm. long; blades flat, rather firm, 5 to 17 cm. long (the uppermost reduced), 2 to 3 mm. wide, long-hirsute on the upper surface at base, papillose-

[1] Received November 8, 1932.

hirsute on the lower surface toward the ends, usually with a few hairs on the upper surface, the margins stiffly ciliate toward base; racemes commonly 2, sometimes 3, approximate (the common axis 5 to 20 mm. long), ascending, often somewhat recurved, 5 to 9 cm. long; rachis flexuous, 1 mm. wide, with a narrow winged margin, glabrous, the margin and midvein above scabrous; spikelets on minute flat pedicels, solitary, scarcely imbricate, 3 mm. long, 1.8 to 2 mm. wide, obovate-elliptic, glabrous; glume and sterile lemma equal, 5-nerved, the lemma slightly concave and sometimes faintly fluted; fruit slightly smaller than the spikelet, smooth and shining.

Type U. S. National Herbarium no. 1,535,768, collected on fine sandy and silty clay loam, near Beaumont, Jefferson County, Texas, September 8, 1932 by J. F. Combs.

This very distinct species belongs in the Notata group but is not closely allied to any of its five North American species.

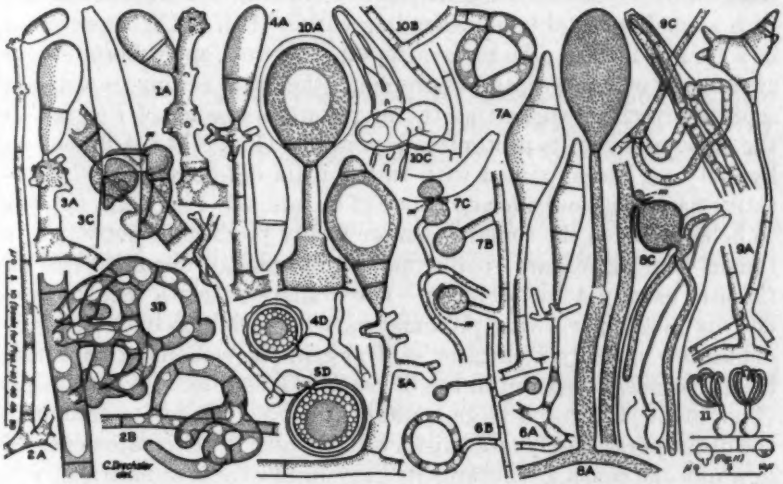
Mr. Combs writes that the species is found only on the Lake Charles soils, derived from sedimentary deposits in the Coastal Plain, and that it is an excellent forage grass, hence the specific name, *almum*, nourishing.

BOTANY.—*Morphological diversity among fungi capturing and destroying nematodes.*[1] CHARLES DRECHSLER, Bureau of Plant Industry.

Nematodes mostly of the genera *Rhabditis* and *Diplogaster* infesting agar plate cultures prepared from plantings of diseased rootlets or other decaying plant materials have been found destroyed often in such enormous numbers that the numerous heaped masses of their remains became visible to the naked eye as scabby superficial deposits. Among these fungi the one (Fig. 1, A) discussed by Zopf[2] as *Arthrobotrys oligospora* Fres. was often encountered. Three species evidently closely related to it and similarly having 1-septate conidia—one (Fig. 2, A) with the markedly smaller spores divided into somewhat less unequal cells and borne usually in one or two whorls on minute sterigmata; another (Fig. 3, A) bearing longer conidia with characteristically tapering basal cells, usually in a single terminal whorl likewise on sterigmata distributed over a recognizable enlargement; and a third (Fig. 4, A) with straight or slightly curved elongated ellipsoidal conidia borne in looser capitate arrangement on a terminal head of stubby branches—showed close similarity to *A. oligospora* also in manner of capture and killing. The animal was caught in one or more of the anastomosing hyphal loops (Figs. 2, B; 3, B) produced abundantly on the surface of the substratum by all

[1] Received February 10, 1933.
[2] Nova Acta K. Leop.-Carol. Deut. Acad. Naturf. 52: 314–341. 1888.

these fungi and coated on their inner surfaces at least in large part with a transparent highly adhesive substance. Soon its integument was narrowly perforated by one or several processes arising usually from the inner face of the loop, and its internal structure fatally disrupted by the rapid intrusion of one or several inflated parts often very largely and sometimes completely occupying the body section involved (Fig. 3, C). Likewise in a species (Fig. 5, A) with 3-septate, obovoid spores borne in loose capitate arrangement on short subapical



Figs. 1–10.—Various nema-capturing fungi, each numeral denoting a separate species, and all species drawn with the aid of the camera lucida at the same magnification; ×500. A, Conidiophore (shown completely only in Fig. 2) with attached conidium of approximately average size, shape and condition with respect to septation. B, Organs of capture, either adhesive hyphal loops or adhesive knob-cells. C, Internal disruptive development of fungus, or its external constrictive swelling, Figs. 3, 7 and 8 showing condition at the time the animal's movements ceased. D, Intramatrical resting reproductive structures. *m*, Adhesive mucous substance. Fig. 11.—Portion of fertile branch of *Harposporium anguillulae*, ×1000.

branches as well as on the apex, large loops often in extensive anastomosing systems are formed, and the same mode of capture, penetration and internal disruption of the animal prevails. In a species (Fig. 6, A) with narrower, 4-septate, spindle-shaped conidia borne similarly in terminal, somewhat loose, branching capitate arrangement, the rather small loops are supplemented by globose cells borne on delicate lateral hyphal branches (Fig. 6, B). These cells, like the homologous but more robust structures (Fig. 7, B) of a closely related species (Fig. 7, A) that produces mostly solitary, 4-septate, broader, spindle-

shaped conidia, capture their prey by means of a strongly adhesive substance which becomes visible as a transparent disc-shaped cushion surrounding the point of contact with the struggling animal (Fig. 7, C). Penetration of the integument and production of an expanded part within ensues as in the case of the loops. It was undoubtedly such adhesive globose cells that Zopf interpreted, in excusable error, as conidia of his *Monosporidium repens*. Capture by adhesion, associated, however, with the formation by the fungus of a strongly inflated, thick-walled, yellow distension mostly outside the animal though with a smaller distal lobe protruding within (Fig. 8, C), is prevalent in a fungus having a large, non-septate, obovoid spore borne singly at the apex of a non-septate sporophore, the latter arising from a non-septate mycelium suggesting the mycelium of species of *Pythium* in the appearance of its protoplasmic contents (Fig. 8, A). Adhesion on hyphal tips, accompanied with rather little differentiation of vegetative parts both outside and inside of the animal (Fig. 9, C), appears to be effective in the somewhat more feebly predacious activity of a fungus bearing solitary spores, inverse pyramidal, distally twice bifurcate, usually 4 to 7 septate,—two transverse septa regularly occurring in the narrowing proximal part, two oblique ones regularly delimiting laterally a third or central cell, the remaining partitions being variously disposed in the divergent lobes (Fig. 9, A). A fungus (Fig. 10, A) bearing a large, solitary, obovoid, 1-septate conidium, the disproportionately large distal cell of which latter is often encased in a mucous coating, captures its prey in mostly intramatrical, vertically oriented hyphal loops (Fig. 10, B), killing it however, not by protrusion of a bulbous outgrowth within the animal's body, but by constriction effected through pronounced swelling of the three loop-cells, the swelling taking place more especially toward the center of the loop (Fig. 10, C).

In addition to the aerial colorless conidia that readily become detached from the rather tall (.1 to .5 mm.) colorless conidiophores present in all the nema-capturing fungi discussed, several species have been found to produce within the substratum yellow resting reproductive structures, usually terminally on single somewhat inflated cells,—the whole arrangements of parts, with the sometimes loosely enveloping outer membrane, curiously suggesting sexual apparatus of certain oomycetes. The seven fungi first referred to, which have been isolated, show in pure culture a correspondence in vegetative and sporulating habits that indicates a much closer natural relationship than distribution among such genera as *Arthrobotrys*, *Cephalo-*

thecium, *Trichothecium*, *Dactylaria*, and *Dactylella* might seem to imply.

The non-predacious parasite described in detail by Zopf as *Harposporium anguillulae* Lohde was also often found highly destructive to nemas in many agar cultures. In undisturbed and well developed material four of the crescentic spores were rather regularly seen attached to the tip of the slender cylindrical outgrowth arising from the spherical part sessile on the fertile branch, thus plausibly characterizing the flask-shaped structure as a basidium, and the fungus as a basidiomycete (Fig. 11).

ZOOLOGY.—*A bivulvar specimen of the nematode* Mononchus muscorum (*Dujardin*) *Bastian.*[1] GERTRUDE HENDERSON CASSIDY, Hawaiian Sugar Planters' Association. (Communicated by G. STEINER.)

Mononchus muscorum (Dujardin) Bastian 1865[2] is a species of wide geographical distribution; in 1930 specimens were found for the first time on the island of Maui, Territory of Hawaii.[3]

During that year considerable numbers of *Mononchus* had been collected from the islands of Oahu, Hawaii, Maui, and Kauai, and specimens of twelve species identified. For the most part observations had been restricted to the lower lying cultivated areas bearing sugar cane and pineapples, but later it was considered advisable to include some of the more remote forest lands and unfrequented mountainous ridges with a view to determining the possible indigenous nematode population of the Hawaiian Islands.

For this reason nemic collections were made at known elevations on the slopes of Haleakala, the highest mountain on the island of Maui. The ascent was made under the direction of the forest ranger and a route selected which is seldom if ever frequented save by an occasional pheasant hunter or by the inspecting forester.

The various collections present a wide range of nematode genera including several species of predacious mononchs,—among them the specimen of *M. muscorum* depicted which was found in loose cindery soil surrounding dandelion roots growing on the east side of the crater at an elevation of 8,000 feet. At this elevation practically all vegetative growth had ceased and only stunted grasses and occasional weeds

[1] Received October 13, 1932.

[2] BASTIAN, H. C. *Monograph on the Anguillulidae.* Trans. Linn. Soc. London. 25: 103. 1865.

[3] CASSIDY, G. *Some Mononchs of Hawaii.* Hawaii. Planters' Rec. 35: 330. 1931.

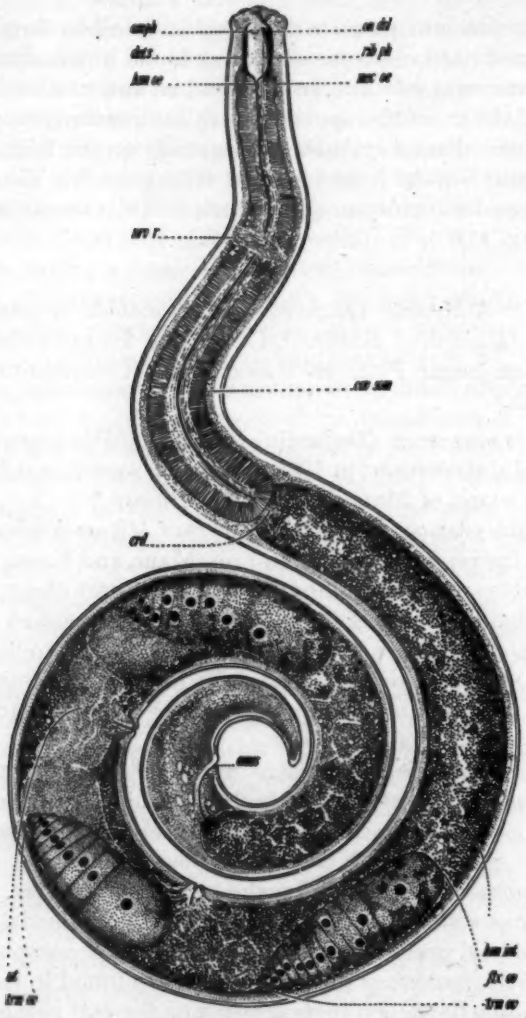


Fig. 1. Bivulvar *Mononchus muscorum: amph*, amphid; *anus*, anus; *cav som*, somatic cavity; *crd*, cardia; *dnts*, pharyngeal teeth; *flx ov*, flexure of ovary; *lum int*, lumen of intestine; *lum oe*, lumen of oesophagus; *msc oe*, musculature of oesophagus; *nrv r*, nerve ring; *on dsl*, dorsal onchium; *rib ph*, pharyngeal rib; *trm ov*, terminus of ovary; *ut*, uterus. × about 200.

were to be found in the coarse cindery deposit of the upper volcanic ridges.

This specimen of *M. muscorum* immediately attracted attention by reason of the abnormality of the reproductive organs. Two well developed vulvar openings are clearly defined: one situated at 55 per cent of the total body length, and the other at 66 per cent. (See Fig. 1.) Three reflexed ovarian tubes are present: one, on the left side, lying anterior to the proximal vulva; the other two situated anterior (left side) and posterior (right side) to the distal vulva. The distal vulva is regarded as more nearly approaching the normal by reason of the slightly better development of the supporting muscles, by its position (normal specimens commonly show the vulvar aperture at about 64 per cent) and because of the paired ovarian tubes and uteri connected with it.

The percentage measurements of this specimen are as follows:

2.7	9.0	23.5	55.0	66.0	91.0	1.7 mm.
3.0	—	4.0	5.0	5.0	3.0	

The percentage measurements of a normal specimen obtained from the same collection are as follows:

2.7	9.0	23.5	64.0	91.0	2.0 mm.
3.0	—	4.0	5.0	3.0	

This is the fourth case of bivulvarity yet recorded from free-living nemas. The first was mentioned by Bütschli[4] for a marine nematode *Linhomoeus mirabilis* Bütschli; the second by Paramonov[5] for the freshwater species *Trilobus gracilis* Bastian, and the third by the present writer[6] for a Dorylaimus species. Undoubtedly all these cases must be considered abnormal or even pathological. The one here described is the most pronounced because it concerns not only a duplication of vulva and vagina, as in the instances mentioned by Bütschli, Paramonov, and Cassidy, but the duplication includes also uterus and ovary.

From the description and figure given by Bütschli, it is assumed that only the anlage of vulva and vagina was doubled and this at a rather late stage of development, judging from the close position of the duplicates.

[4] BÜTSCHLI, O. *Zur Kenntniss der freilebenden Nematoden, insbesondere der des Kieler Hafens.* Abhandl. d. Senckenb. naturf. Gesell. Frankfurt a.M. 9: 33. 1874.

[5] PARAMONOV, A. *Über einen Fall von "Bivulvarität" bei einem freilebenden Nematoden.* Russ. Hydrobiol. Ztschr. 5: 218–222. 1926.

[6] CASSIDY, G. *A meristic variation in a female nematode.* Nature 121: 476–477. 1928.

The same was apparently true for *Trilobus gracilis* described by Paramonov, but here the duplicates are more distant, suggesting a somewhat earlier separation.

In the bivulvar Dorylaimus previously recorded by the present writer there were two vulvae 0.062 mm. apart, each with a vagina, a uterus, and an ovary. This suggests that a separation of the paired anlage of the anterior and the posterior branch of the female apparatus took place, since normally these dorylaims are amphidelphic.

In the *Mononchus* here described the duplication involves the whole anterior branch of the normal female apparatus suggesting a separation of its anlage at a very early date of its development, but still at a time when the anlage for the normal female apparatus would have already divided into its anterior and posterior branch.

The causes for these duplications are unknown. It is remarkable that they all concern female specimens and that up to the present no such duplications have been observed in male nematodes.

ZOOLOGY.—*Two new species of Isopod Crustaceans from California.*[1]

J. O. MALONEY, U. S. National Museum. (Communicated by WALDO L. SCHMITT.)

In the course of his studies on littoral ecology at Monterey Bay, California Coast, Dr. G. E. MacGinitie of the Hopkins Marine Station obtained, among other crustaceans, two species of isopods of the family Idotheidae which seem never to have been described, *Synidotea macginitiei* and *Pentidotea montereyensis*. The description of each is based on a male holotype preserved in alcohol.

A specimen from San Francisco Bay, however, has been taken as the type of *S. macginitiei*, as Dr. MacGinitie's specimens were small and with adult characters not fully developed. The specimens from San Francisco Bay were identified by earlier workers as *Synidotea laticauda*,[2] though they are more closely related to *Synidotea bicuspida* (Owen).[3]

Synidotea macginitiei, new species

Description.—Body ovate, length 15 mm., width 7.25 mm. (third and fourth thoracic segments widest). Head 2.5 mm. long, 3.25 mm. wide, with

[1] Published by permission of the Secretary of the Smithsonian Institution. Received November 30, 1932.

[2] BENEDICT, JAMES E. *A revision of the genus* Synidotea. Proc. Acad. Nat. Sci. Philadelphia, 1897. 389–404. *figs. 1–13.*

[3] RICHARDSON, H. *Monograph on the Isopods of North America.* U.S.N.M. Bull. 54: pp. i–liii, 1–727. *figs. 1–740.* 1905.

front produced on either side of a median excavation in a narrow border, the lateral portions of which form an angle with the dorsal portion as in *S. bicuspida*. Eyes not visible in a ventral view, small, round, and situated on either side some distance from lateral margin which is expanded to form a narrow border. First and second articles of first antenna about equal in length; third, one and one-half times length of second; fourth a little shorter than third. First pair of antennae extend to middle of fourth peduncular joint of second pair. Basal and second articles of second antenna about equal in length, basal article not visible in dorsal view; third and fourth each about twice as long as second; fifth nearly as long as third and fourth together. Flagellum consists of fifteen articles. terminal one tipped with a tuft of hairs. Second antenna extends to posterior margin of third thoracic segment. Ventral side of left outer lobe of first maxilla consists of eleven tooth-like spines, many of them denticulate, and one long tapering spine. Some of the long plumose hairs of outer lobe of second maxilla extend to second joint of second antenna. (See Fig. 1.)

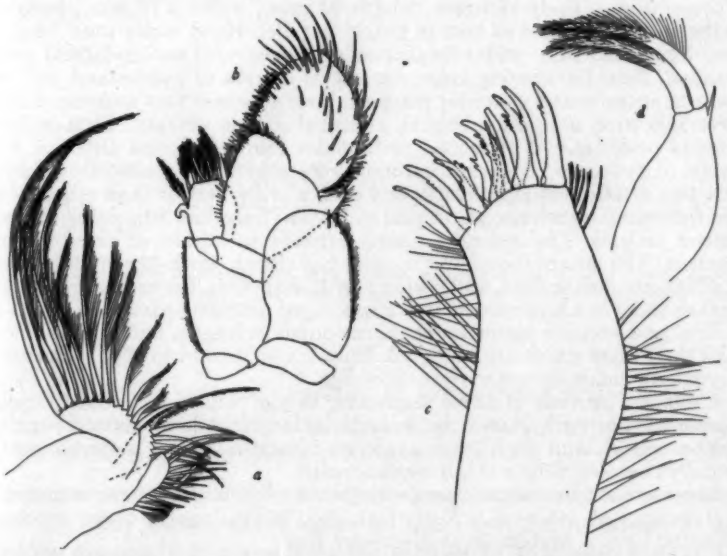


Fig. 1.—*Synidotea macginitiei*, new species. *a*, right second maxilla. *b*, left maxilliped; *c*, left first maxilla, outer lobe. *d*, left first maxilla, inner lobe.

The first segment of the thorax, measured on the median dorsal line, is the shortest, following segments subequal. Lateral margins of segments almost straight.

Abdomen triangular in shape, length 6.75 mm., with median notch at apex of terminal segment. Telson is similar to that of *S. bicuspida*, and is as wide at base as it is long. The legs are similar in shape; propodus, carpus, and merus thickly beset with hairs on inner margin.

Color in alcohol a yellowish-brown with irregular markings of dark brown. These markings prominent on head and longitudinal median portion of

body. Sides of head below eyes and epimera with many small splotches of dark brown.

Holotype.—A male, U.S.N.M. Cat. No. 66413 taken by the *Albatross* in San Francisco Bay, California has been selected as the type. Dr. MacGinitie collected six specimens at Monterey Bay, of which the largest is 9.5 mm. long. The species is named for him, as it was his material which first called my attention to this new species.

Remarks.—This species is close to *S. bicuspida*, the more noticeable differences being in the head and mouth parts. The frontal margin is more nearly straight and the eyes more laterally situated in *S. bicuspida* than in *S. macginitiei*. A prominent lateral margin below the eyes is absent in *S. bicuspida*. The epipod of the maxilliped, the outer lobe and relative length of its plumose hairs of first maxilla, and the teeth and denticulations of outer lobe of second maxilla are different in the two species.

Pentidotea montereyensis, new species

Description.—Body elongate, length 25 mm., width 3.75 mm., length of abdomen 8 mm.; sides of thorax nearly parallel. Head wider than long, 4.5 mm. long, 3.25 mm. wide; frontal margin excavate, antero-lateral angles rounded. Eyes moderately large, on lateral margin of head about half way between anterior and posterior margins. First article of first antenna dilated, three following articles subequal, terminal article clavate. First antenna extends to distal end of second peduncular joint of second antenna. First article of peduncle of second antenna very short, not visible from above; next two articles equal in length and each a trifle shorter than either of the two following, which are also equal in length; flagellum consisting of about sixteen articles. The second antenna extends to middle of third thoracic segment. The outer lobe of first maxilla has eleven tooth-like spines, several of which are denticulate, and a long hair-like spine in the center. On ventral surface there is a large setule in a cup-shaped articular cavity.

First and seventh segments of thorax equal in length, and a little shorter than the others which are subequal. Epimera on second to fifth segments do not extend entire lateral margin. (See Fig. 2.)

Abdomen consists of three segments, two of which are small; terminal segment long, with lateral indications of a partially coalesced segment. Telson convex and slightly excavate on lateral margins; posterior portion broadly rounded with a small median point.

Legs similar in structure; propodus beset with hairs on inner margin.

Holotype.—A male, U.S.N.M. Cat. No. 66414, one of three specimens collected by Dr. McGinitie at Monterey Bay.

Remarks.—This species stands near *Pentidotea aculeata* Stafford,[4] differing mainly in the shape of thoracic segments, their epimera, and median notch of telson. The lateral margins of the first three thoracic segments of *P. aculeata* are more angulate, while those of *P. montereyensis* are almost straight; the median notch in *P. aculeata* is much longer; and all the epimera of *P. aculeata* extend to posterior margin, while in *P. montereyensis* only the last two epimera do so.

[4] STAFFORD, B. E. *Studies in Laguna Beach Isopoda.* Jour. Ent. Zool. Claremont. Cal. 5: 182–188. *figs. 6–10.* 1913.

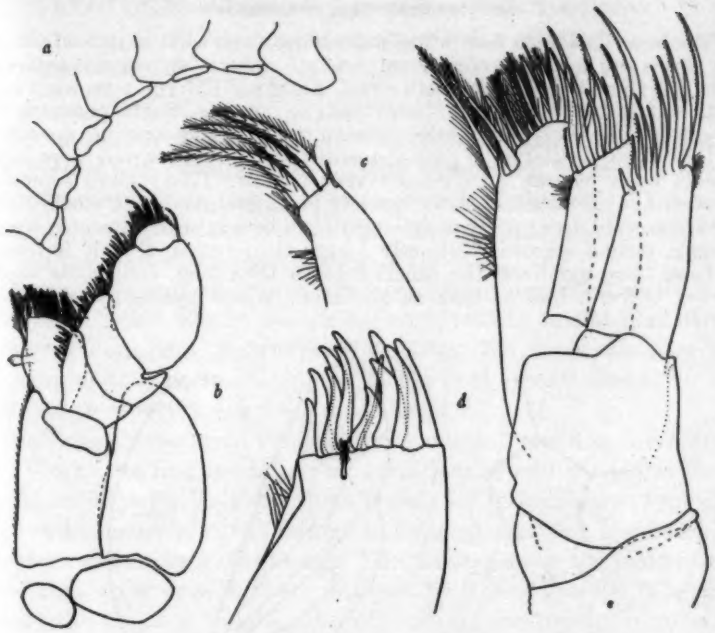


Fig. 2.—*Pentidotea montereyensis*, new species, *a*, right lateral side of thorax showing epimera. *b*, left maxilliped. *c*, left first maxilla, inner lobe. *d*, left first maxilla, outer lobe. *e*, left second maxilla.

ENTOMOLOGY.—*A new parasite of* Laspeyresia molesta *Busck.*[1]

T. UCHIDA, Hokkaido Imperial University, Sapporo, Japan. (Communicated by HAROLD MORRISON.)

Laspeyresia molesta Busck, a very destructive pest of pears and apples, each year causes great losses to fruit culture in Japan. It is, therefore, necessary to investigate the control of this pest. I have to date found only one species of the family Ichneumonidae, *Ephialtes laspeyresiae* Uchida, parasitic on *L. molesta*. But R. A. Cushman, of the United States Bureau of Entomology, has just sent me specimens of a second species reared from this host in Japan. This beneficial insect appears to me to be new to science, and I describe it below.

My best thanks are hereby extended to R. A. Cushman, who sent me this valuable material.

[1] Received November 7, 1932.

Dioctes molestae, new species

Female.—Head with fine, white pubescence, somewhat narrowed posteriorly; frons and face finely coriaceous punctate, opaque; clypeus not separated from face; mandibles stout, teeth equal. Antennae filiform, somewhat more than half as long as body. Thorax opaque, densely, finely punctate and pubescent like the head; mesopleurum with nearly opaque speculum; scutellum flat; areolation of propodeum distinct, costulae strong, area superomedia open behind, area basalis very narrow. Tibial spurs somewhat shorter than metatarsus; claws sparsely pectinate. Abdomen weakly compressed toward apex; postpetiole longer than broad, nearly smooth, weakly shining, second segment distinctly longer than broad, a little impressed at base, third quadrate, the others broader than long. Ovipositor weakly curved upward, half as long as abdomen. Wings hyaline; disco-cubitus curved in middle.

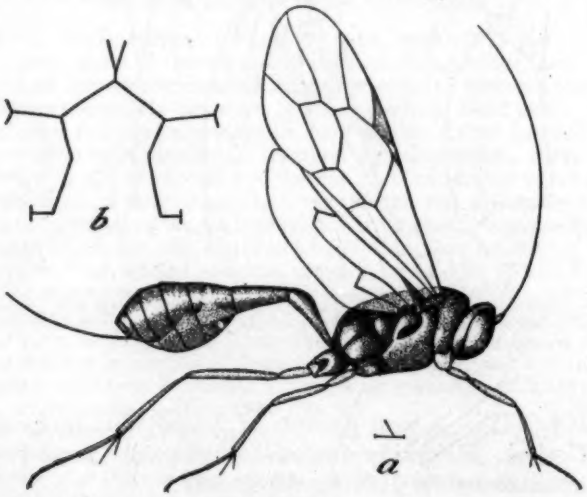


Fig. 1. *Dioctes molestae* n.sp. *a*. Lateral view. *b*. Areolation of propodium.

Length.—5–6 mm.; antennae 4 mm.; ovipositor 2 mm.

Black and opaque. Antennae brownish black to black; scape and pedicel yellowish brown below. Mandibles except apex, palpi, front and middle coxae, all trochanters and ventral plica of abdomen whitish yellow; legs ferruginous, hind coxae, middle coxae, and hind trochanter basally, black; hind tibia and tarsus apically brownish. Abdominal segments 2–4 more or less dark brown, especially at sides. Stigma dark brown.

Male.—Unknown.

Type-locality.—Japan.

This species is related to the European species, *D. crataegellae* Thoms., from which it differs in the color of the abdomen and in the length of the ovipositor.

ARCHAEOLOGY.—*Hopewell type pottery from Louisiana.*[1] F. M. SETZLER, U. S. National Museum. (Communicated by JOHN R. SWANTON.)

Owing to the fact that up to the present time only two vessels have been found south of the Ohio River[2] which are recognized as belonging to the Hopewell culture in the Upper Mississippi Valley,[3] it seems highly important to bring to the attention of archeologists a general description of the pottery vessels and other artifacts discovered in the east central part of Louisiana, near Marksville.

The pottery and associated artifacts herein described were excavated by Gerard Fowke during his explorations in the Red River Valley of Louisiana, February–May, 1926. No illustrations or description of the specimens appear in his final report[4] though in the preliminary report[5] a few were reproduced.

Analysing the restored vessels from Mounds 4 and 8 in the Marksville Works, we find the following variations of and resemblances to the Hopewell pottery: (Fig. 1) One vessel may be considered typically Hopewell because of such features as the cross-hatched band and bisected cones just beneath the rim. The decoration on the body of the vessel consists of smooth bands outlined by incised grooves. The area outside the bands is roughened uniformly by means of the roulette, and a conventionalized eagle is outlined on each of the four lobes. (Fig. 2.)

We also find two flat bottom bowls decorated on the inside and outside of the rim with triangular notches. A constriction near the middle of each cone-shaped vessel divides the decoration into two distinct parts. The figures on the lower half have been outlined by incised grooves forming conventionalized birds, the head of each suggesting the eagle. The area outside the smooth bands has been roughened by means of the roulette. The motif on the upper half is again outlined by incised grooves and consists of heart and pear-shaped

[1] Published by permission of the U. S. National Museum, Smithsonian Institution. Received October 28, 1932.

[2] MOORE, C. B. Jour. Acad. Nat. Sci. Phila. **13**: 286–88. *figs. 3, 4, and 5*: 1908.

[3] For a detailed description of Hopewell characteristics, see: MILLS, W. C., and SHETRONE, H. C. *Exploration of Hopewell Group.* Certain Mounds and Village Sites in Ohio. **4**: pt. 4, 297–305. 1926; SHETRONE, H. C. *Culture Problems in Ohio Archaeology.* Amer. Anthropologist. n. ser. **22**: No. 2, 144–172. 1920; SHETRONE, H. C. and GREENMAN, E. F. *Exploration of the Seip Group of Prehistoric Earthworks.* Ohio Archaeol. and Hist. Quart. **40**: No. 3, 343–509. 1931.

[4] FOWKE, G. *Archaeological Investigations.* 44th Ann. Rep., Bureau of American Ethnology, Pt. 2, 405–434. 1928.

[5] FOWKE, G. *Archaeological Work in Louisiana.* Smithsonian Misc. Coll. **78**: No. 7, 254–59. 1926.

objects and meandering or curvilinear bands which have been polished. The rest of the area is uniformly roughened by means of the roulette.

On a fourth vessel the manner of outlining by deeply incised grooves and the zigzag roughening bears resemblance to the aforementioned

Fig. 1. Hopewell vessel, probably from Mound 2 of the Mound City Group near Chillicothe, Ohio. Originally in the collection of Dr. Edwin Hamilton Davis. Reproduction of a drawing from *Sketches of Monuments and Antiques; found in the Mounds, Tombs and Ancient Cities of America*, p. 49, The portfolio of Dr. Davis' collection is in the manuscript room of the Bureau of American Ethnology.

ones. However, the band of decoration below the rim is radically different from the typical Hopewell design, yet it is closely comparable to that on one of the other vessels. This jar also has lightly incised parallel lines running at a forty-five degree angle which probably indicate an incomplete cross-hatched design such as is found on the typical Hopewell jars.

Another vessel too has the characteristic smooth bands outlined

with grooves while the rest of the surface is roughened. Instead of the typical cross-hatch and punctate design below the rim, it has only the line of punctates or bisected cones while the area directly above it, which is usually cross-hatched, is smooth.

Still another vessel has the beginning of what appears to be the

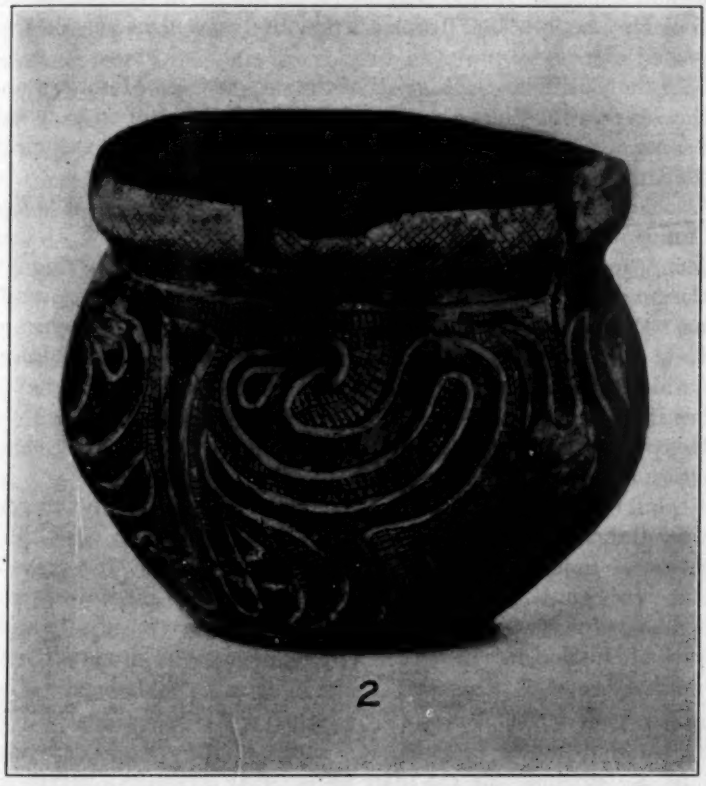


Fig. 2. The most typical Hopewell vessel from the Marksville Works. From Mound 8. Dia. 3¼ inches; H. 4¼ inches. U. S. Nat. Mus. Cat. No. 331688.

cross-hatched design below the rim, but the area around the neck differs from any design found on the typical northern Hopewell specimens. This consists of a series of three parallel grooves one inch long and a series of nine indentations, three rows of three each, made with a blunt instrument. The fact that this vessel was found associated with the typical Hopewell vessels from Mound 4 would seem to be sufficient evidence that it belongs to the same culture, although it em-

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bodies an entirely different method of decoration, i.e., the concentric grooves with narrow polished bands between. The method of decorating vessels with concentric grooves and smooth narrow bands, although it differs radically from the typical Hopewell, was found on one miniature vessel to form two conventionalized eagles. This conventionalized eagle design certainly resembles the designs on the more typical Hopewell vessels from Marksville, as well as on numerous Hopewell objects.[6]

This analysis indicates that all of the vessels from Mounds 4 and 8 of the Marksville Works show a definite relationship to each other and some of them closely resemble vessels from the Hopewell culture in the Upper Mississippi Valley.

Associated with the pottery in Mounds 4 and 8, Mr. Fowke found the following artifacts: Monitor or platform pipe of clay, $3\frac{1}{4}$ inches long, $1\frac{1}{16}$ inches wide and $1\frac{3}{4}$ inches high at the bowl. The diameters of the bowl measured from the outside in each case are $1\frac{1}{16}$ and $1\frac{1}{8}$ inches. Fragmentary base of another platform pipe, $2\frac{1}{2}$ inches long and $\frac{3}{16}$ inch wide. Three projectile points. Sandstone rubbing or smoothing stones. Impressions in clay of a vertically plaited matting, consisting of over-two-under-two technique.[7]

The platform pipes and matting imprints are outstanding characteristics of the Hopewell culture in the north.

A tabulation has been made of the decorated vessels and sherds illustrated and described in various publications[8] dealing with the excavation of mounds in the Upper Mississippi Valley recognized as having been built by Indians possessing Hopewell characteristics.

It seems obvious from such a tabulation that the most outstanding feature of the decoration on the Upper Mississippi Hopewell vessels

[6] For other examples embodying conventionalized eagle designs, see: MILLS, W. C *Exploration of Mound City Group.* Certain Mounds and Village Sites in Ohio. **3**: pt. 4, 354–359. *figs. 60, 61, 62, 63, 64, 65.* 1922.

[7] For similar matting from an Ohio Hopewell mound, see: MILLS, W. C. Op. cit., 382. *fig. 81.*

[8] WILLOUGHBY, C. C. *Turner Group of Earthworks, Hamilton County, Ohio.* Papers of Peabody Mus. Amer. Archaeol. and Ethn., Harvard Univ. **8**: No. 3. 1922; MOOREHEAD, W. K. *Hopewell Mound of Ohio.* Field Mus. Nat. Hist., Anthrop. Ser. **6**: No. 5, 75–178. 1922; MILLS, W. C., and SHETRONE, H. C. *Exploration of Hopewell Group.* Certain Mounds and Village Sites in Ohio. **4**: pt. 4, 79–305. 1926; SQUIER, E. G., and DAVIS, E. H. *Ancient Monuments of the Mississippi Valley.* Sm. Contrib. to Knowledge. **1**: 187–190. 1848; MILLS, W. C. *Exploration of Edwin Harness Mound.* Ohio Archaeol. Hist. Quart. **16**: No. 2, 113–193. 1907; SHETRONE, H. C., and GREENMAN, E. F. *Explorations of the Seip Group of Prehistoric Earthworks.* Ohio Archaeol. Hist. Quart. **40**: No. 3, 343–509. 1931; MILLS, W. C. *Exploration of Mound City Group.* Certain Mounds and Village Sites in Ohio. **3**: pt. 4, 245–406. 1922. *Exploration of the Tremper Mound.* Idem **2**: pt. 3, 105–240. 1917. *Exploration of Seip Mound.* Idem **2**: pt. 1, 1–57. 1917; MCKERN, W. C. *Wisconsin Variant of the Hopewell Culture.* Milwaukee Public Mus. Bull. **10**: No. 2, 185–328. 1931.

and sherds is that surfaces of 31 show bands of various dimensions outlined with deeply incised grooves and the areas between or outside the grooves uniformly roughened either by roulette, zigzag, punctate or cord marks. Nineteen of the illustrations show that the area just below the rim of the jars has been decorated with incised cross-hatched lines and an encircling line of bisected cones. The forms vary, there being 12 bowls, 11 jars, and 2 vases. There are five examples of supporting feet. Seven jars are shaped with four lobes—the predominant style—one with six, and one with three lobes. Twelve have round bases, seven have pointed bases, and five have flat bases. No applied pigment is used for decoration.

With regard to the decoration on the vessels and sherds from Mounds 4 and 8 in the Marksville Works, we find that 9 of the 12 restored vessels have bands outlined by deeply incised grooves, and the bands or the remaining parts of the vessel were uniformly roughened —on three specimens by means of the roulette, three by concentric grooves or bands, two by means of zigzag lines and one by the punctate method. On four of the jars the area just below the rim is decorated with cross-hatched incised lines and the encircling line of bisected cones. Thus far a similarity is obvious. The tempering used in the Marksville pottery differs radically, however, from that common to the northern Mississippi type. In the former, either pulverized potsherds or particles of hard clay are used; in the latter, grit or shell. The bases of all the Marksville vessels, so far as could be determined, were flat. Four of the Marksville vessels are bowls, four vases, three jars and one is unique. Only one is four lobed.

This comparison between the Marksville and the recognized Hopewell wares shows a close similarity and one of the vessels from Marksville is a type identical with northern Hopewell. Independent invention of so complicated a technique of decoration where there is such striking similarity would seem impossible. Further investigations may throw additional interesting light on the distribution of the Hopewell Culture. In Ohio, where the center of this highly developed mound building culture is located, no evidence has been found which enables anthropologists to say to what ethnological or linguistic group these Indians belonged. It would seem from the above facts that Louisiana, Mississippi, and perhaps Arkansas must be considered in the distribution of Hopewell traits. These similarities in the south may be due to commercial intercourse but, nevertheless, they are important.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

248TH MEETING

The 248th meeting of the Academy was held in the Assembly Hall of the Cosmos Club on Thursday, April 7, 1932, President ADAMS presiding. About 150 persons were present.

Program: ARTHUR HOLMES, Professor of Geology, University of Durham, England: *The thermal history of the earth.*

249TH MEETING

The 249th meeting of the Academy was a joint meeting with the Geological Society of Washington, held in the Assembly Hall of the Cosmos Club, Thursday, November 17, 1932. About 150 persons were present. President ADAMS called the meeting to order at 8:20 P.M., and introduced Doctor DOUGLAS JOHNSON, Professor of Physiography, Columbia University, who delivered an illustrated address on *Some problems of the arid landscape.* He discussed the history of land changes as recorded in the erosion surfaces seen in the arid districts. The land forms found were attributed to the eroding power of streams forming fans which were traceable in simple and compound form in widely separated areas of the earth. Several members discussed the paper from the floor.

250TH MEETING

The 250th meeting of the Academy was a joint meeting with the Philosophical Society of Washington, held in the Assembly Hall of the Cosmos Club, on Thursday, December 15, 1932, President L. H. ADAMS presiding. About 175 persons were present.

Program: PAUL R. HEYL, Bureau of Standards: *Romance or Science:*—The elusive and unreal character of modern physical concepts has suggested in certain quarters that perhaps physicists are suffering from the effect of too much learning. It can be shown, however, that the present state of physical theory is the logical result of an evolution whose guiding principle has been that of simplicity and economy of thought, as laid down by Occam and Newton, that no more causes than are sufficient are to be assigned for the explanation of phenomena, a principle regarded for six centuries as the most approved rule of philosophy. If the application of this principle leads us to concepts which appear romantic, perhaps this is because for the first time in the history of human thinking we have come close enough to reality to catch a glimpse of it. (*Author's abstract.*)

CHARLES THOM, *Recording Secretary*

PHILOSOPHICAL SOCIETY

1041ST MEETING

The 1041st meeting was held in the Cosmos Club Auditorium, Saturday evening, October 8, 1932, President TUCKERMAN presiding.

Program: C. B. WATTS: *The U. S. Naval Observatory Eclipse Expedition to Maine* (illustrated).—The Naval Observatory party was located in Limington, Maine, near the village of Limerick, and was under the direction of Commander C. H. J. Keppler, U.S.N. Photographs of the corona were

made with cameras of various sizes, ranging from one of 65 feet focal length down to a motion-picture camera of 17 inches focal length. While thin clouds cut down the fainter portions of the corona considerably, the large camera gave excellent detail in the inner corona. The times of contact were observed visually and with the motion-picture camera. (*Author's abstract.*)

H. W. FISK: *Eclipse observations of the Department of Terrestrial Magnetism, Carnegie Institution of Washington* (illustrated).—In accordance with its custom, the Department of Terrestrial Magnetism made use of the occasion of the total solar eclipse of August 31, 1932, to collect additional data bearing upon a possible effect on the magnetic field due to the passage of the Moon's shadow across the Earth.

The observations undertaken on this occasion were very simple, consisting of eye-readings of declination only, using the ordinary field-magnetometer. Three stations were established within the belt of totality, two being about equally distant from the center line in northern Vermont and western Maine, in approximately the same latitude, the third being near the center line, farther south, on the New Hampshire-Maine border.

The days preceding the eclipse were characterized by a moderate magnetic storm, which had nearly disappeared by the day of the eclipse. A comparison of the graphs drawn from the observations at the three stations showed a very close identity of curve for the three field-stations, and these were very similar in detail to the curves taken from the Agincourt and Cheltenham magnetograms. An interesting feature apparent on each of the curves was a small but very distinct fluctuation which occurred immediately after totality at the field-stations and coincided quite exactly with the time the shadow crossed the New England coast-line and passed out over the sea. The occurrence of this small disturbance after many hours of normal diurnal-movement was quite startling and its coincidence with totality was very suggestive of a possible connection, although it is recognized that the coincidence may have been entirely fortuitous.

Previous investigations have led to the conclusion that the eclipse-effect on the magnetic field is that of a dimunition in the expected departure of a value of an element from its daily mean value, and that this takes place somewhat gradually during the entire interval during which the Moon's shadow falls upon the Earth. Superimposed upon this general effect there has been detected another effect corresponding to the local eclipse-interval. However, because of other irregularities which are continually occurring and which are entirely independent of the eclipse, it is only by a discussion of a large mass of data that conclusions may be safely reached. (*Author's abstract.*)

S. S. KIRBY and T. R. GILLILAND: *The radio eclipse observations of the Bureau of Standards* (illustrated).—Radio observations made in Washington and Nova Scotia by the Bureau of Standards during the solar eclipse of August 31 were described. Professor Chapman in England had suggested that the lower of the two observed ionized regions of the upper atmosphere was caused by bombardment of neutral corpuscles shot out from the sun while the upper region was thought to be caused by ultra-violet light. It was calculated that the path of the particle eclipse should lie to the north and east of the optical path and that the particle eclipse should occur two hours before the other. Since the lower radio frequencies are returned to earth from the lower ionized region at about 100 km. height while the higher frequencies are returned from the upper region at a height of about 220 km. or

more, it was thought that if solar corpuscles were responsible for the lower region ionization, then changes would be noted in the radio signals being returned from that region two hours before the optical eclipse occurred. At Sydney, Nova Scotia, which was within the predicted path of the particle eclipse, a record was made of the virtual height from which reflections occurred for a frequency of 2400 kc. This frequency was ordinarily just low enough to be returned from the lower region during the early afternoon. If particles were largely responsible for the lower region ionization, it was expected that reflections would begin to occur from the upper region by 1:30 P.M. However, no changes were noted until the optical eclipse began to take effect at which time reflections began to come from the upper region.

Besides the observations on 2400 kc. readings were made of critical frequency, which is, roughly speaking, the frequency above which strong reflections do not come from the lower region. This was found to drop with the occurrence of the optical eclipse. Similar observations made in Washington were also described.

It was concluded that ultra-violet light is the principal factor responsible for ionization in both the lower and upper regions. If the effect of solar corpuscles is present, it is small compared to that of ultra-violet light. (*Author's abstract.*)

The above papers were discussed by Messrs. MEGGERS, DAVIS, and TUCKERMAN.

An informal communication was presented by G. H. DRAPER, who discussed Fermat's theorem and concluded with details of his solution of the problem. The communication was discussed by Mr. HEYL.

A second informal communication was presented by W. J. HUMPHREYS, which consisted of a description of a tree that had been struck in a peculiar manner by lightning. The lightning in this case traversed lengthwise through the center of the tree instead of along the Cambium layer, that is just under the bark. The communication was discussed by Messrs. CRITTENDEN and TUCKERMAN.

G. R. WAIT, *Recording Secretary*

1042ND MEETING

The 1042nd meeting was held in the Cosmos Club Auditorium, Saturday evening, October 22, 1932, President TUCKERMAN presiding.

Program: H. L. CURTIS: *The attitude of European laboratories towards absolute electrical units* (illustrated.)—During the summer it was my privilege to visit the Bureau International des Poids et Mesures, the Laboratoire Central d'Electricite, the Physikalisch-Technische Reichsanstalt, and the National Physical Laboratory. At all of these laboratories there is an agreement that units more closely approaching the absolute units should be adopted as early as practicable. Researches are under way to fix units in all the laboratories except the Bureau International des Poids et Mesures. The question naturally arises as to whether the fixing of the units should await completion of all of these researches as well as the researches at the Bureau of Standards and the Japanese national laboratory. The National Physical Laboratory is farthest along with its researches and members of its staff would like to see the absolute units adopted at the earliest possible date. At the Physikalisch-Technische Reichsanstalt, researches on absolute units are just getting well started so that it will be several years before results are obtained. However, many members of the staff feel that the urgency for

changing units is so great that international action should not await completion of these researches. At the Laboratoire Central d'Electricite the staff is agreeable to an early change in the units. I believe that the opinion of the majority of the members of the staffs of these laboratories is that efforts should be made to have the new units adopted January 1, 1935. (*Author's abstract.*)

Discussed by Mr. BRICKWEDDE.

C. MOON: *Some problems encountered in the absolute determination of the ohm* (illustrated).—This paper gives a brief description of the numerous problems encountered in the absolute determination of the ohm from mechanical and electrical measurements on standards of self inductance.

Single layer solenoids can now be constructed so accurately that the uncertainty in their computed inductance due to variations in the diameter and pitch of the winding are negligible. The necessary mechanical measurements of diameter and pitch of the winding can be made with a probable error of only a few parts in a million. In the electrical measurements the maximum variation of a single value from the mean is only one part in one hundred thousand. However, the possibility of an unknown systematic error is somewhat greater than in the mechanical measurements.

Results obtained from measurements on two standard inductors indicate that at the present time resistance can be determined in terms of the fundamental units of length and time with a probable error of less than one part in one hundred thousand. (*Author's abstract*).

Discussed by Mr. MACKAVANAGH.

R. W. CURTIS: *A redetermination of the international ampere in absolute measure* (illustrated).—From the definition of the unit of current it is possible to measure currents by means of the standards of length, mass, and time. The old tangent galvanometer was one method of doing this, but the difficulties are very great when accurate measurements are required.

In this work the force between one coil hung on a balance beam and two other coils is measured. The force depends only upon the current in the coils and the relative positions of the coils. The relative radii of the coils is measured electrically in a separate experiment. By means of this experimentally measured ratio of radii and the experimentally determined force, and the known value of the acceleration of gravity, the current flowing through the coils can be computed. The result is the value of the current in absolute measure. At the same time the current is measured in the usual way with a standard resistance and standard cell, and this result is called the value of the current in international measure. The ratio of the international ampere to the absolute ampere does not depend on the current, and should be constant. The results of this experiment are expressed as this ratio.

Eight experimental determinations of the ratio of radii of four sets of coils gave results which were self-checking and showed errors no larger than ± 6 parts in a million.

Three series of determinations of the force with three sets of coils give results in which the maximum deviation from the mean is about 24 parts in a million. The final result can be expressed as

$$1 \text{ B.S. International Ampere} = 0.99991_9 \text{ Absolute Ampere.}$$

This is in substantial agreement with the result of a similar determination made by Rosa, Dorsey and Miller in 1911, which was

$$1 \text{ B.S. International Ampere} = 0.99992_8 \text{ Absolute Ampere.}$$

(*Author's abstract.*)

An informal communication was presented by F. E. JOHNSON on *Fermat's Theorem*. He analyzed the solution presented informally by G. H. Draper in a previous meeting of the Society and showed that this solution is not valid.

FRANK WENNER, *Acting Recording Secretary*

1043RD MEETING

The 1043rd meeting was held in the Cosmos Club Auditorium, Saturday evening, November 5, 1932. President TUCKERMAN presiding.

Program: W. R. GREGG: *Winds: Some of their characteristics* (illustrated).—Wind is the result of variations in pressure, which in turn are caused by differences in temperature. Because of the earth's rotation the wind does not blow directly from high to low pressure, but is deflected to the right in the northern hemisphere, to the left in the southern. On a level surface, with no friction present, the motion would be at right angles to the pressure gradient, or parallel to the isobars, and the speed would be in accordance with the well-known gradient equations, which involve the pressure gradient, angular velocity of the earth, air density, and latitude. Because of friction and turbulence, however, the theoretical values are never realized at or close to the Earth's surface. The direction is always across the isobars at an angle ranging from 10° to 40°, depending on the amount of friction, and the velocity falls short of the theoretical value by 50 to 200 per cent.

Winds near the earth's surface are, moreover, characterized by an almost endless series of abrupt changes, generally known as gustiness. Sudden departures of the order of 30° to 45° from the mean direction and increases or decreases of 30 to 50 per cent in the velocity are not uncommon. Departures of 90° to 135° in the direction and 60 to 75 per cent in the velocity occasionally occur. Their effect on structures and on the operation of aircraft depends on their abruptness and on the period during which they are maintained. Accelerations of 30 to 50 miles per hour per second have been observed but they continued for only a fraction of a second. Accelerations of 5 to 10 miles per hour per second, lasting for 2 or 3 seconds are, however, quite common. Gustiness is most pronounced during the daytime when thermal turbulence is active. The gusts produced thereby are of much longer periods, often 2 or 3 minutes or more, than are the purely frictional gusts, the latter being superposed on the former.

The effects of gustiness rapidly diminish with height and practically cease at 400 to 500 meters above the surface. At these and greater heights the winds are generally in accord with the gradient equation and, though differing widely in individual cases, on the whole increase with height to the top of the troposphere, about 11 kilometers in middle latitudes, and are prevailingly from a westerly direction. In the stratosphere, where an entirely different type of pressure and temperature distribution prevails, the winds are variable in direction and decrease markedly in velocity. (*Author's abstract.*)

Discussed by Mr. HUMPHREYS.

F. NEUMANN: *Vibration observations in the Washington Monument* (illustrated).—A small portable experimental seismograph developed by the Coast and Geodetic Survey, in connection with the study of destructive movements in the central region of an earthquake, was set up several times in the Washington Monument to test its performance. The data thus obtained are of special interest to engineers and physicists desiring to study the

physical characteristics of tall structures. It was pointed out that the recorded movements are so small that for all practical purposes they can be considered negligible, certainly so when compared with the vibrations of tall office buildings. As the maximum displacements in a strong wind are only a few thousandths of an inch they can be observed only with a very sensitive type of seismograph, an instrument of the same order of magnification as found in modern seismographic equipment for recording the unfelt vibrations emanating from distant earthquakes.

The instrument used is a pendulum of 1 oz. mass suspended at the free end of a flat spring free to vibrate horizontally. Damping is obtained through the frictional characteristics of a thin film of castor oil inserted between the bottom of the disk-shaped mass and the smooth surface of a glass or metal platform built beneath the mass. A mirror axle of 1 mm. diameter, suspended vertically, furnishes one of the elements of the magnifying system, which is optical. In practice this axle is suspended from a fine silk thread as a safety measure, but the thread plays a negligible part in the instrument performance. Two very fine phosphor-bronze ribbons which are strung horizontally close to the axle, are cemented to the frame at their four terminals and each is wound one time around the mirror axle in the same direction. A similar ribbon, strung parallel to the other two, is cemented to the ends of an adjustable fork or prong fixed to the steady mass and projecting a short distance beyond it. This ribbon is wound around the mirror axle in a direction opposite to that of the other two. The effect of the combination is such that when the pendulum is displaced a slight amount of the ribbon strung across the end of it causes the mirror axle to rotate on the other two ribbons which may be considered as taking the place of a jewel and pivot bearing. The advantages of this scheme are the practical elimination of lost motion, a minimum of friction and high magnification. The ribbons are 0.01 mm. thick and 0.1 mm. wide; magnification can be varied from 1000 to several thousand, and periods from 1/15 second or less to 1 second. A suitable recording apparatus for photographic registration is part of the assembly.

The fundamental vibration period of the monument was found to be 1.81 seconds. An overtone of 0.6 second period was observed visually and is vaguely evident in some of the photographic records. On another occasion a period of 0.2 second appeared as the outstanding characteristic of the record, and again, during a gusty type of rain-storm the dominant vibrations were close to 0.06 second or a frequency of 17 per second. These few observations are insufficient to explain the various modes of vibration, especially in view of the fact that only one component of a 3-dimensional type of vibration was recorded. The value of the fundamental period and overtones are of the order to be expected, but the observed frequency of 17 oscillations per second appears to the physicist as a rather curious phenomenon. (*Author's abstract.*)

Discussed by Messrs. HUMPHREYS, STIMSON, HAWKESWORTH, BLAKE, HECK and DRYDEN.

H. L. DRYDEN: *Wind pressure on a model of the Empire State Building* (illustrated).—When the Empire State Building was constructed in New York City, provision was made through the cooperation of architects, engineers, and owners to have the building serve as a laboratory for obtaining more accurate knowledge of wind pressure. Under the direction of the committee on research of the American Institute of Steel Construction, thirty pipes were placed at the 36th, 55th, and 75th floors, transmitting the pressure from small openings in the exterior faces of the building to accessible places

on each floor. In addition, some of the steel columns under the tower portion of the building on the 23rd floor were provided with strain gauges for determining strains in the columns due to wind. Instruments for measuring the direction and velocity of the wind were mounted on the top of the building.

The forecasting of the wind pressure to be expected on a building has many of the aspects of a game of chance. It is practically certain that the speed of the wind will exceed 5 miles per hour at some time during nearly every day of the year. In Washington, D.C., the speed will exceed 40 miles per hour about four times a year. It has not blown at a speed of 100 miles per hour at the Weather Bureau station in Washington, D.C., in the sixty years or so that records are available. It is a practical impossibility to design all buildings to withstand the maximum speeds which have ever been experienced anywhere. The engineer must draw the line at some speed which is not likely to be exceeded in the life of the building. To obtain information of this kind from direct observations on a building would require years of measurements, and a statistical study of the results. Moreover, the results would not necessarily be applicable to some other building of a different shape.

The only long-continued observations on the wind are those made by the Weather Bureau. These observations give the wind speeds, and to determine the pressure on the building, the relation between the pressure and the speed must be known. The method of obtaining this relation, which is now coming into use, is that of making measurements on models in a wind tunnel, a device in which artificial winds may be produced. Although the method of model-testing is well known in hydraulics and aeronautics and has been found invaluable, it is new to structural engineers. Full confidence has not been placed in the results, because of some feeling of uncertainty as to the application to buildings in the natural wind. When the program of the American Institute of Steel Construction to be carried out on the Empire State Building was announced, the Bureau of Standards saw an opportunity to demonstrate the utility and validity of model measurements. Experiments have been completed on a model of the building at the Bureau of Standards. When the results on the actual building are finally available, comparisons can be made.

The Empire State Building is 1250 feet high; the model is 5 feet high. On this scale the height of a man would be a little more than one-quarter inch. The model is built of aluminum plates to the exterior shape of the building omitting minor irregularities of the surface. It does not represent the actual building in material, method of construction, or strength. It is not tested to failure but is used only for measurements of wind pressure. Small holes in the outer walls are connected by rubber tubing to a pressure gauge. The air near the surface of the model pushes on the air in the rubber tubing with the same pressure as on the neighboring solid wall of the model. The pressure is transmitted to a gauge where it is balanced by the weight of a column of liquid. In some tests the model was mounted in bearings and the overturning moment measured.

The artificial wind was produced in the 10-foot wind tunnel of the Bureau of Standards, in which speeds up to 70 miles per hour may be obtained.

Under normal conditions, with no wind blowing, the surfaces, both interior and exterior, of all buildings, are subjected to the normal atmospheric pressure of 14.7 pounds per square inch. When the wind blows, this pressure is modified. In some places the pressure increases, in others it decreases by amounts which usually do not exceed a few tenths of a pound per square

inch. When the pressure is reduced below the normal atmospheric pressure, the effect is often called a suction. The results on the model of the Empire State Building, show as for other models tested that the pressure varies greatly from point to point and that suction effects predominate. The greatest loads on the building occur when the wind blows directly against one face. The average pressure is of the order of 35 to 40 pounds per square foot at a wind speed of 100 miles per hour. At other wind speeds, the pressure varies as the square of the speed, i.e., at 50 miles per hour, it is only 9 or 10 pounds per square foot.

It was found that the speed of the air rushing by close to the building is greater than that of the approaching wind. Thus the instrument on the building gives a speed about 20 per cent greater than the speed of the wind approaching the building.

The detailed results giving charts of the distribution of pressure with the wind striking the model from different directions will be published in a few months as a Research Paper of the Bureau of Standards. (*Author's abstract.*)

Discussed by Messrs. HECK, BITTINGER, and HAWKESWORTH.

1044TH MEETING

The 1044th meeting was held in the Cosmos Club Auditorium, Saturday evening, November 19, 1932, President TUCKERMAN presiding.

Program: D. H. ANDREWS, Professor of Chemistry in The Johns Hopkins University: *Models of vibrating molecules* (illustrated).—Before the advent of the new quantum mechanics we thought and talked of atoms and molecules in terms of definite models which were useful in the formulation of mathematical equations and in the physical interpretation of the results of theoretical and experimental investigations. In the new mechanics, models are so difficult to construct that they are little used, and with the annunciation of Heisenberg's Uncertainty Principle, their overthrow as a useful aid seemed complete. Models were replaced by mathematical abstract quantities, like ψ, and by symbolisms. It is interesting that Professor Andrews is using models to obtain *quantitative* results that are useful, not only in correlating the results of numerous investigations of Raman spectra of complex molecules, but also in discovering facts previously unknown.

Professor Andrews demonstrated models which he had used in the study of the modes and frequencies of the vibratory motions of atoms in molecules. The atoms were replaced by steel balls connected by springs to represent the chemical bonds holding them together. The ratios of the masses of the steel balls are as the ratios of the atomic weights of the atoms and the springs were so selected that their stiffnesses correspond with the relative strengths of the bonds. The models are suspended freely and are made to vibrate by a variable-speed motor to which they are loosely coupled. In order to make it possible to see and count the vibrations, the illumination of the model was periodically varied so that the observed frequency of vibration of the atoms was only 1/20th the actual frequency. When the frequency of the motor corresponds with a natural frequency of the model it vibrates in resonance with the motor, but when the speed of the motor is increased or decreased a little the model ceases to vibrate. Starting with the motor turning slowly, one observes, if its speed is increased continuously, one after another of the different modes of vibration of the molecule. The corresponding frequencies of vibration are the frequencies of rotation of the motor.

Although the agreement of the model frequencies with the known molecular frequencies determined spectroscopically is not exact, the correspondence

is close. This makes it possible to determine the modes of vibration corresponding with the numerous frequencies obtained from Raman spectra investigations. There are cases where frequencies were first observed with the model and later found in the Raman spectra. By combined model and Raman spectra investigations of homologous series, one is enabled to follow the changes in molecules as new groups are added one after the other. With the models information can be obtained as to the structures of molecules as was obtained for example with regard to the position of the double-bond in benzene, and the angle between the C-Cl bonds in C Cl_4. (*Abstract prepared by* F. G. BRICKWEDDE.)

Discussed by Messrs. RAMBERG, HERSEY, WHITE, TUCKERMAN, CURTIS, GIBSON, HUMPHREYS, and BRICKWEDDE.

An informal communication was presented by W. P. WHITE, in which he described a method of preparing an ice-bath of very constant temperature.

1045TH MEETING

The 1045th meeting, constituting the 62nd annual meeting, was held in the Cosmos Club Auditorium, Saturday evening, December 3, 1932, President TUCKERMAN presiding.

The treasurer reported expenditures of $1500.19 and stated that the number of active members is 275.

The Secretaries reported that the following new members were elected during the year: CLYDE S. AITCHISON, MISS ELIZABETH W. ALDRICH, L. B. ALDRICH, REBECCA E. ANDREWS, DAVID W. ARMSTRONG, EMMETT CHESTER BAILEY, P. S. BALLIF, HERBERT GEORGE BAROTT, HOWARD S. BEAN, FORREST GARY BITNER, RAYMOND B. BLOCK, ROY C. BOWKER, F. S. BRACKETT, DONALD B. BROOKS, DONALD M. BROWN, SIDNEY H. BROWN, HOWARD A. BUCHHEIT, FRANK R. CALDWELL, JAMES ROBERT COE, JR., RAYMOND DAVIS, ORRIN M. ELLIOTT, MELVIN F. FISCHER, CYRUS C. FISHBURN, JAMES FULTON FOX, RALPH W. FRENCH, FREDERICK H. GOLDMAN, CARLETON B. GREEN, HOMER A. HAMM, ROBERT C. HARDY, ORLANDO J. HODGE, W. H. HOOVER, MISS M. LANGHORNE HOWARD, CURTIS J. HUMPHREYS, S. H. INGBERG, DEANE B. JUDD, H. K. KING, FREDERICK L. KNOWLES, FRANK C. KRACEK, MISS CHARLOTTE M. KRAMPE, W. LERCH, MRS. ISABEL MARTIN LEWIS, HENRY MATHESON, E. D. MCALLISTER, PAUL A. MCNALLY, ARCHIBALD T. MCPHERSON, PAUL S. MURPHY, REV. JOHN S. O'CONOR, S.J., GEO. C. PAFFENBARGER, OLIVER SCOTT READING, W. A. ROCHE, WILLIAM FREDERICK ROESER, CARL RUSSO, PRENTIS D. SALE, JR., MRS. ELSIE W. SHAW, E. R. SHEPHARD, JOHN C. SOUTHARD, SYDNEY STEELE, LOYD A. STEVENS, ALLEN RAYMOND STICKLEY, WM. H. SWANGER, HERBERT C. S. THOM, JOHN TUCKER, JR., DAVID LINDSAY WATSON, CLARENCE C. WEIDEMANN, EDWARD WICHERS, and J. U. YOUNG.

The following deaths were reported: LOUIS WINSLOW AUSTIN, LOUIS A. BAUER, GEORGE K. BURGESS, ROBERT L. FARIS, HENRY MARTIN PAUL, IRWIN G. PRIEST, and FREDERICK W. STEVENS.

The following officers were declared elected for the year 1933: *President*, O. S. ADAMS; *Vice Presidents*, H. L. DRYDEN and O. H. GISH; *Recording Secretary*, F. G. BRICKWEDDE; *Treasurer*, E. W. WOOLARD; *Members-at-large of the General Committee*, L. B. ALDRICH and H. T. WENSEL.

During the year the second Joseph Henry lecture in memory of the first President of the Philosophical Society was given by A. E. KENNELLY, Professor Emeritus of Electrical Engineering at Harvard University.

At the conclusion of the business meeting, F. B. SILSBEE read a paper on *Superconductivity*.—This paper summarizes the more outstanding facts which have been found during the 21 years since the property of superconductivity was discovered by Professor Kamerlingh Onnes at Leiden. Most of these facts are the result of work at Leiden, but during the last few years many valuable contributions have come from the German Reichsanstalt and from the University of Toronto.

Superconductivity, like cosmic radiation and radioactivity, is one of the relatively few phenomena of physics which has been discovered unexpectedly, rather than as the result of a deliberate search. The electrical resistances of certain substances such as mercury, lead, and tin at the very low temperature made available by the use of liquid helium, drop abruptly at their respective critical temperatures, 4.2°K, 7.2°K, and 3.7°K, to values too small to measure. In the case of lead the resistance has been found to be certainly less than 10^{-12} times the resistance of the same specimen at room-temperature. This superconducting state is destroyed and normal resistance abruptly restored if the substance is placed in a sufficiently strong magnetic field, or if the electric current used in measuring the resistance is so great as to produce a magnetic field of the critical value.

Changing the crystal state of the metal as in the change from the ordinary "white" tin to "gray" tin also destroys the superconductivity.

Other materials which have been found to show this property are the elements, gallium, indium, thallium, titanium, thorium, columbium, tantalum, and such compounds as the nitrides of titanium, vanadium, circonium; the carbides of titanium, tungsten, molybdenum, tantalum, columbium, and zirconium; and the sulphides of copper and of lead. An alloy of gold and bismuth is also superconducting at 1.8°K, although neither of the separate constituents shows this property when tested down to 1.5°K.

This astonishing change by a factor of a million million is one property which does not seem to be accompanied by any abrupt change in any other properties. The crystal structure as revealed by X-rays, the thermal expansion, coefficient of torsional rigidity, and thermal conductivity all change but little and in a perfectly continuous fashion as the material is cooled down through its critical temperature.

The experiments so far performed have raised more questions than they have answered. Is the increased conductivity the result of an increased number of carriers of electricity, or of an increased freedom of those already present? Is the resistance below the critical temperature truly zero, or does it have a finite value beyond the limit of the methods of measurement thus far tried? Will all metals, and perhaps all substances, be found to be superconducting if cooled to a sufficiently low temperature? And, most tantalizing of all, will any substance be found which under certain conditions will be superconducting at ordinary temperatures and thus revolutionize the art of electrical engineering? (*Author's abstract.*)

Discussed by Messrs. CURTIS, WHITE, BARROWS, BRICKWEDDE, GOLDMAN, HAWKESWORTH, HUMPHREYS, BUCKINGHAM, and TUCKERMAN.

G. R. WAIT, *Recording Secretary*

BOTANICAL SOCIETY

240TH MEETING

The 240th regular meeting was held in the Assembly Hall of the Cosmos Club on March 1, 1932. President J. B. S. NORTON presided; about 145 were present.

L. E. YOCUM was elected to membership.

Brief notes and reviews: M. B. WAITE exhibited daffodils from his yard. He recalled that in 1890 there was a similar mild winter. F. V. COVILLE and A. S. HITCHCOCK reported further upon seeds caught from airplanes. J. S. COOLEY exhibited a culture of *Xylaria malli* showing zonation. J. B. S. NORTON reported finding sclerotia of brown rot of peaches one half to three fourths of an inch long. M. B. WAITE reported peaches in bloom in Arkansas, whereas here and in Georgia the buds have not swollen, being still dormant due to lack of chilling. R. F. GRIGGS exhibited a culture of liverwort growing on nitrogen-free agar which was strongly phototropic.

Program: W. J. MORSE: *Agricultural explorations in Japan, Korea and Manchuria.*—Illustrated by four reels of motion pictures taken by the speaker during his two year stay in the Orient. Culture of soybeans and utilization of the crop was shown in detail. Other scenes illustrated the growing of rice, small fruits and other crops, as well as the Japanese cherry tree and other ornamentals in bloom, and the collecting, packing and shipping of the material collected.

After adjournment, soybean cheese sandwiches and soybean chocolate milk were served. Other soybean food products were exhibited.

SPECIAL MEETING

A special meeting was held in the Conference Room of the Administration Building, U. S. Department of Agriculture, March 22, 1932. President J. B. S. NORTON presided; 47 members and guests were present.

Program: T. H. HARRISON, plant pathologist of New South Wales: *Plant Pathology in Australia.*—The speaker outlined the principal physical and climatic characteristics of the states of Australia together with a brief statement of the organizations which are responsible for scientific work. From the investigator's viewpoint, Australia is a very young country. Although the size of the United States of America, it has only about seven million inhabitants. Only the easily accessible and fertile land has been developed. Crops grown and the diseases which attack them were discussed in detail, many being illustrated by lantern slides.

241ST MEETING

The 241st regular meeting was held at the University of Maryland, April 5, 1932. President NORTON presided; 179 members and guests were present.

Dinner was served in the College dining hall at 7:30. This was followed by a dramatic sketch put on by a small group of University of Maryland students, entitled, "Suppressed Desires."

Program: B. Y. MORRISON: *English Gardens.*—The speaker visited several of the famous gardens in England and had an opportunity to observe the personal interest which the Englishman takes in his garden. Exhibits of Narcissi illustrated the results of crossing certain strains.

242ND MEETING

The 242nd regular meeting was held in the Assembly Hall of the Cosmos Club on May 3, 1932. President J. B. S. NORTON, presided; attendance 66.

MISS VIVIAN KEARNS was elected to membership.

Brief notes and reviews: FRANK THONE exhibited four new volumes, Baillieres Encyclopedia of Scientific Agriculture; Proceedings of the 5th International Botanical Congress at Cambridge; Murray's Planning and Planting the Home Garden; and Life of Mendel. C. A. LUDWIG exhibited

cowpea, alsike clover and Lespedeza plants grown without sunlight. J. B. S. NORTON showed an unusual violet.

Program: K. D. DOAK: *Mycotrophic habit in Allegheny forest trees.* (Illustrated by lantern slides).—Discussed by C. A. LUDWIG, J. B. S. NORTON, F. THONE, C. HARTLEY, R. D. RANDS and others.

J. S. COOLEY: *Some wild flowers of Oregon.* (Illustrated by lantern slides.)—Discussed by D. GRIFFITHS, R. K. BEATTIE and M. C. MERRILL.

ANNUAL OUTING

The annual outing was held at the Montgomery Sycamore Island Club on June 4, 1932, attendance, 115. Games and swimming were enjoyed. About 5 o'clock coffee and ice cream were served by the Society to members and guests who provided their own lunches.

NATHAN R. SMITH, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

Death Valley now a National Monument.—An important step in the development of the U. S. National Park system was taken on February 11, when by presidential proclamation the greater part of Death Valley was withdrawn from the open public domain and given the status of a national monument. The area set aside is 1,601,800 acres in extent, and takes in about two-thirds of the total land in the valley. It includes particularly the land below sea level, which is the lowest point in the Western Hemisphere. Within the area are such notable natural features as Telescope Peak, Furnace Creek, and the Ubehebe Crater. Within it also is the famous Death Valley Scotty's Place, a fantastic rococo palace built by a "character" who seems to have money to burn and chose to spend it on building.

Abbé Lemaitre lectures in Washington.—The abbé GEORGES LEMAITRE, noted physicist of the University of Louvain, lectured at the Catholic University of America on January, presenting some of his views on the "expanding universe" postulated by Einstein and De Sitter, for whose divergent theories he has found mathematical reconciliation. Extrapolating the cosmic expansion backwards in time, Abbé LEMAITRE comes to a beginning as a single atom of sufficient mass (or its energy equivalent) to have since formed all the matter in the universe. The initial explosion of this cosmic atom the Abbé sees as the origin of the cosmic rays, which are thus as old as the universe itself.

Mechanical tabulation of oceanographic data.—The problem of utilizing the information relating to ocean currents, sea temperatures, and concomitant phenomena contained in the thousands of reports received monthly by the Hydrographic Office of the U. S. Navy has been greatly simplified by the use of electrical punching, sorting and tabulating equipment, recently installed.

This system is one in which data are represented by holes punched in certain positions on a card. The punched cards can then be sorted into desired groups, by an electrical sorting machine, and finally tabulated and analyzed by an electrical tabulator which prints a record of the operation.

Static bearing indicators.—The Navy has been interested for many years in the correlation of static with violent weather disturbances. Experiments have been conducted with various types of instruments and it has been found that the use of a cathode ray tube to show the direction of incoming atmospherics is the most promising.

Two such instruments have been designed and manufactured at the Naval Research Laboratory and are now ready for installation. It is planned to locate them at Naval direction finder stations in Florida and Texas, so that by plotting instantaneous cross bearings of incoming atmospherics, weather disturbances can be located even in the absence of ship reports.

Public health work in Costa Rica and Cuba.—In the February issue of the *Bolétin de la Oficina Sanitaria Panamericana*, Drs. A. PENA CHAVARRIA and MARIO LUJAN report the results of the Dick test in Costa Rica. Among 852 persons, 21.4 per cent proved positive, as compared with 34.4 per cent (Zingher) in New York City and 13.1 per cent (Doull, et al.) in Rio. The percentage of positivity decreased in San Jose from 55 per cent in infants under 1 year to 38 per cent, in children 1 to 4 years; 24.4 per cent, 5 to 9 years; 22.2 per cent, 10 to 14 years; 18.2, 15 to 19 years; and 13.2 per cent in persons over 20.

Among persons of the white race, the percentage was 20.9 in the urban districts and 20 in the country sections, compared to 26.1 and 17.3, respectively, among persons of mixed races. These tests were made during a recent epidemic of scarlet fever in Costa Rica. This epidemic proved one of the most extensive ever observed in the country, and judging from its renal complications, the most serious so far during the present century. The disease is very rare in Costa Rica, and the records only show an epidemic in 1901 and another in 1865.

Dr. PENA CHAVARRIA had previously made similar studies with the Schick test in Costa Rica and Colombia.

Vernon Bailey returns.—After conducting a three-months biological expedition in northern Mexico, VERNON BAILEY returned on January 25 to his Washington headquarters in the Bureau of Biological Survey, United States Department of Agriculture. With FREDERIC WINTHROP, JR., of the Museum of Comparative Zoology, at Cambridge, Mass., and BERNARD BAILEY, a collector from Escondido,Calif., he covered a section of country extending from the backbone of the Sierra Madras at 8,500 feet down to sea level on the Gulf of California, near Tiburon Island. This section included parts of all the life zones between the Canadian and Tropical, with the accompanying wide variation and complexity of plant and animal life. Besides making an excellent mammal and bird collection, which is to be divided between the Biological Survey and the Museum of Comparative Zoology, the expedition gathered a wealth of valuable information on habits and distribution of species and on the limits of the life-zone areas of the region and their relation to those of the United States.

Examine more than 2,000 mammal stomachs.—The Biological Survey's food-habits research laboratory, in Denver, Colo., during 1932 received 4,260 mammal stomachs, including more than 3,600 of coyotes and 370 of wild cats. The laboratory reports that 636 of the 2,663 stomachs studied were empty and 535 contained only debris picked up by the animals while in traps. Valid data were thus collected of the contents of 1,492 stomachs, 1,379 of which were of coyotes.

News Briefs

Chinese civilization dates back only to about 2000 B.C., and is thus much more recent than that of the Nile-Mesopotamia-Indus area, an investigation by C. W. Bishop, curator of the Freer Gallery, indicates. Mr. Bishop obtained his data by adding up the probable durations of the reigns of monarchs in the Chinese dynasties. According to his chronology, the Hsia dynasty, the first of "civilized China" began about 1800 B.C.

On December 30 the United States Department of Agriculture issued Importation Permit No. 20,000. Dr. T. S. Palmer, of the Bureau of Biological Survey, who is in charge of the work, says this means that since the passage of the Lacey Act on May 25, 1900, permits have been issued for the entry of 20,000 separate shipments of birds and mammals.

Personal Items

Dr. Theobald Smith, who was the first chief of the pathological division of the Bureau of Animal Industry, recently retired as director of the Rockefeller Institute at Princeton University. It was Dr. Smith who discovered, while he was a member of the department that the cattle tick carries tick fever from one animal to another, a discovery which paved the way for the later discovery that the mosquito transmits malaria and yellow fever.

Walter G. Campbell, Director of Regulatory Work in the U. S. Department of Agriculture, resigned to become Chief of the Food and Drug Administration in the department, effective February 1. The position of Director of Regulatory Work has been abolished.

Dr. Walter Hough, Head Curator of Anthropology, has gone to Arizona, for a two-month sojourn among the Pima Indians of the Mexican border. Dr. Hough expects to obtain photographs of fast-vanishing types, and also to inspect archaeological undertakings now under way in that area.

Dr. W. D. Strong, of the Bureau of American Ethnology, sailed January 28 for Hondruras, where, in company with Alan Payne and Norman Haskell, he will conduct archaeological researches in the Chorotegan area. One of the principal objects of the expedition is the search for a reported "stone city" in the region of the Patuca River.

Miss Emma Reh, formerly of Washington, now Science Service correspondent in Mexico City, is at present in the field in the State of Oaxaca with a party of Mexican archaeologists, exploring the famous tomb group at Monte Alban and investigating other sites.

Dr. Emmet W. Price, parasitologist, Zoological Division, United States Bureau of Animal Industry, left Washington January 19 for Puerto Rico, as one of a group of scientists, headed by Dr. Paul Bartsch of the Smithsonian Institution, who will spend two months in the Caribbean.

Ernest J. Greenwalt has been appointed agent and United States deputy game warden to supervise the Charles Sheldon Wild Life Refuge, Nevada, which is administered by the Bureau of Biological Survey, in cooperation with the National Association of Audubon Societies, chiefly for the protection of antelope.

E. N. Munns, in charge of the Division of Silvics, U. S. Forest Service,

has been elected vice president of the Permanent Committee, governing body of the International Union of Forest Research Organizations.

Dr. WILLIAM BOWIE, Chief of the Division of Geodesy, U. S. Coast and Geodetic Survey, has been awarded the Charles Lagrange prize by the Royal Academy of Belgium in recognition of his having effected the unification of the triangulation systems of Canada, the United States, and Mexico. This prize is awarded once in four years for work done which adds to the mathematical knowledge of the earth.

Obituary

Dr. FRANCIS LA FLESCHE, of the Bureau of American Ethnology, died September 5, 1932. Dr. La Flesche was born in Thurston County, Neb., Dec. 25, 1857. He was three-quarters Indian, his father being Estamaza, a half-blood who was the former head chief of the Omaha tribe, and his mother a full-blood Indian. He became prominent in 1878–1879 when he and his elder sister Susette accompanied the Ponca chief Standing Bear in his journey to the East. Here the wrongs which the Ponca (a tribe whose language is nearly identical with that of the Omaha) had suffered were exposed. This led to his appointment in 1881 in the Office of Indian Affairs where he remained for years. After being loaned to the Bureau of American Ethnology, eventually he was transferred to the latter institution. His most important works are The Omaha Tribe (with Alice C. Fletcher), The Osage Tribe: rite of the chiefs; The Osage Tribe: rite of the Waxo be; The Osage tribe: the rite of vigil; The Osage Tribe: two versions of the child-naming rite; A dictionary of the Osage language. He was president of the Anthropological Society of Washington in 1922–23. In 1926 the degree of Doctor of Letters was conferred upon him by the University of Nebraska.

Miss HELEN E. STOCKBRIDGE, librarian of the U. S. Forest Service, died December 20, 1932.

Mr. ERNEST DANGLADE, formerly of the U. S. Bureau of Fisheries, died December 18, 1932, at Vevay, Indiana.

ANNOUNCEMENTS OF MEETINGS

The ACADEMY announces a meeting on March 23, 1933. Members of the Academy and their wives will gather at the East Building of the Bureau of Standards, at 8 P.M., for the purpose of viewing scientific exhibits. The exhibits will cover the different fields in which Academy members are interested, including, among others, biology, chemistry, geology, and physics. An exhibit of special interest to the ladies will be shown.

The Philosophical Society announces the following programs:

March 25. *Studies of atomic nuclei at the Department of Terrestrial Magnetism.*

April 8. R. WIEBE.—*The experimental determination of some properties of gases up to 1000 atmospheres.*

W. E. DEMING.—*Some thermodynamic properties of real gases from compressibility data.*